AD-A038 059 ROME AIR DEVELOPMENT CENTER GRIFFISS AFB N Y F/G 9/2

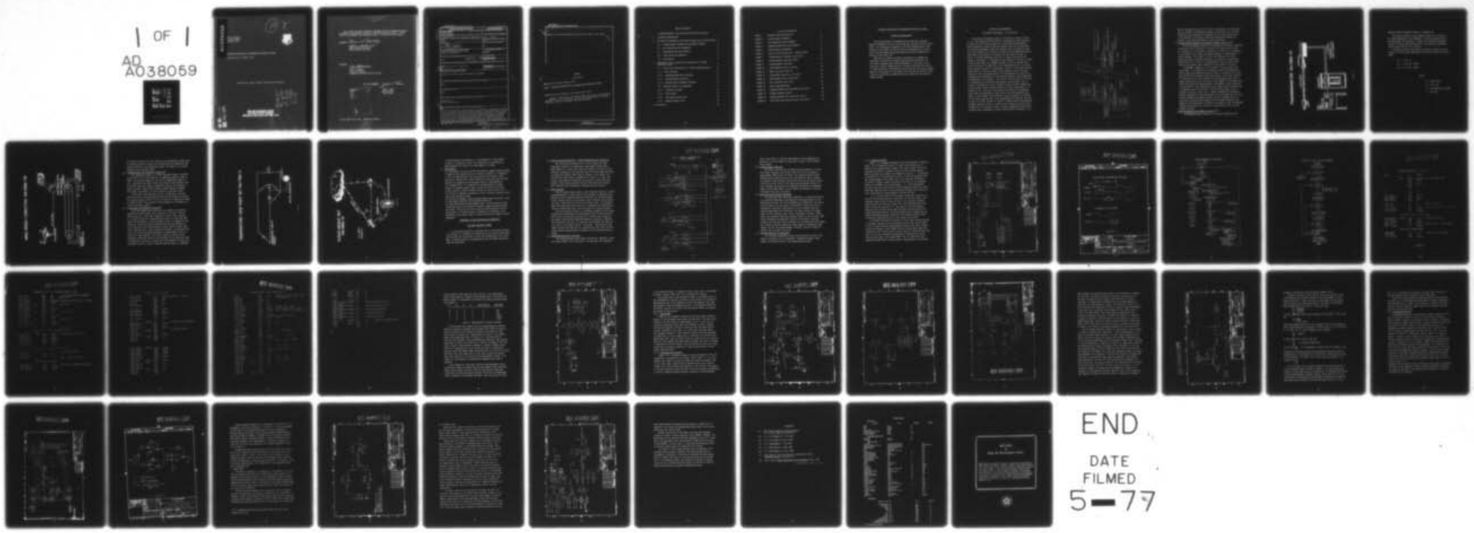
AUTOMATED WEATHER DATA DISSEMINATION FEASIBILITY MODEL.(U)

FEB 77 B L MASSON

UNCLASSIFIED RADC-TR-76-332 NL

1 OF 1

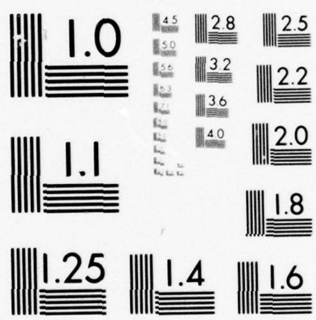
AD A038059



END

DATE FILMED

5-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RADC-TR-76-332
In-house Report
February 1977

AUTOMATED WEATHER DATA DISSEMINATION FEASIBILITY MODEL

Captain Brian L. Masson, USAF

Approved for public release; distribution unlimited.

ROME AIR DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
GRIFFISS AIR FORCE BASE, NEW YORK 13441

This report has been reviewed by the RADC Office of Information and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

APPROVED: Laurence W. Doubleday

LAURENCE W. DOUBLEDAY, Chief
Comm Transmission Branch
Comm & Control Division

APPROVED:

Fred I Diamond

FRED I. DIAMOND
Technical Director
Communications and Control Division

FOR THE COMMANDER: John P. Huss

JOHN P. HUSS
Acting Chief
Plans Office

Do not return this copy. Retain or destroy.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
14 1. REPORT NUMBER RADC-TR-76-332	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
6 4. TITLE (and Subtitle) AUTOMATED WEATHER DATA DISSEMINATION FEASIBILITY MODEL.		5. TYPE OF REPORT & PERIOD COVERED Final - In-house
		6. PERFORMING ORG. REPORT NUMBER N/A
7. AUTHOR(s) 10 Captain Brian L. Masson		8. CONTRACT OR GRANT NUMBER(s) N/A
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rome Air Development Center (DCC) Griffiss AFB NY 13441		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS R1700102
11. CONTROLLING OFFICE NAME AND ADDRESS Same 12 49p. 11		12. REPORT DATE February 1977
		13. NUMBER OF PAGES 42
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Same 9 Final rept.,		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Weather Data
Microprocessor-based

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a study conducted to determine the feasibility of developing an inexpensive microprocessor-based system to accept raw weather data from Air Force inventory sensors and process this data for display. A feasibility model was built at RADC with an Intel Model 8080 microprocessor and attempts were made to interface with the following sensors: the AN/GMQ-13 Rotating Beam Ceilometer, the AN/GMQ-10 Transmissometer, the AN/TMQ-11 Temperature/Dew Point Sensor, and the AN/GMQ-20 Wind Instrument. This report details the over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

309 050

20.

design of the feasibility model and discusses the results of the study.

ERRATA

April 1977

RADC-TR-76-332 dated February 1977

Title: AUTOMATED WEATHER DATA DISSEMINATION FEASIBILITY MODEL

Please add the following on the inside front cover:

Readers of this report are advised that some of the illustrations included herein are relatively poor quality reproductions of computer printouts. They are, however, the best available.

TABLE OF CONTENTS

Automated Weather Data Dissemination Feasibility Model

LIST OF ILLUSTRATIONS

AUTOMATED WEATHER DATA DISSEMINATION FEASIBILITY MODEL

1. INTRODUCTION/BACKGROUND

The present method of disseminating and displaying terminal weather information on an Air Force base does not meet the Air Force's needs. This problem was recognized at the GEEIA Meteorological Conference in July 1968[1] and the Air Force's requirements for an Automated Terminal Weather Dissemination/Display System (ATWDDS) were detailed in AFCS ROC 7-69.

RADC has performed an in-house investigation of methods for automation and potential problems associated with automation. At this time it appears that recent developments in the areas of A/D conversion, digital communications, and data processing could result in a more versatile, cost-effective system than was previously thought possible. The purpose of this report is to outline the results of the study and to describe an ATWDDS feasibility model that has been designed by RADC.

2. THE NEED FOR AUTOMATION; THE PRESENT SYSTEM AND ITS DEFICIENCIES

The system configuration used for illustration, shown in figure 1, is in use today at Griffiss AFB NY. Configuration varies from base to base, but the Griffiss system can be considered representative. Data originates at sensors along the runway, which will be described in following paragraphs. There are identical sets of sensors on each end of the runway, all of which are cabled into the Remote Observation Site (ROS), which houses an indicator for each type of sensor. A switch in the ROS determines which set of sensors (one end of the runway or the other), is connected to the indicators. The ROS is linked to the outside world via a BAUDOT teletype circuit to Carswell AFB, and to the rest of the home base via an electrowriter net. An electrowriter system consists of a transmitter, which is a roll-paper writing tablet with an electrical output, and a receiver, which is an automatically driven roll-paper tablet. The transmitter and receiver are connected with telephone wire, and anything written on the transmitter is reproduced on the receiver. The Griffiss electrowriter net consists of transmitters at the ROS and Base Weather Station (BWS), and receivers at the BWS and 9 other locations such as the SAC command post and the control tower. Anything written on either transmitter is reproduced on all receivers. The system is used mainly to disseminate sensor data and observations from the ROS. The wind speed/direction sensor is also cabled into the BWS and 5 other locations via the ROS. Each of these locations has a wind speed/direction indicator identical to that at the ROS. The BWS is linked to Carswell AFB by approximately 4 BAUDOT teletype circuits. A closed circuit television system links the BWS with 13 locations on base, including command posts and pilots briefing rooms. Viewgraphs or charts placed before the camera at the

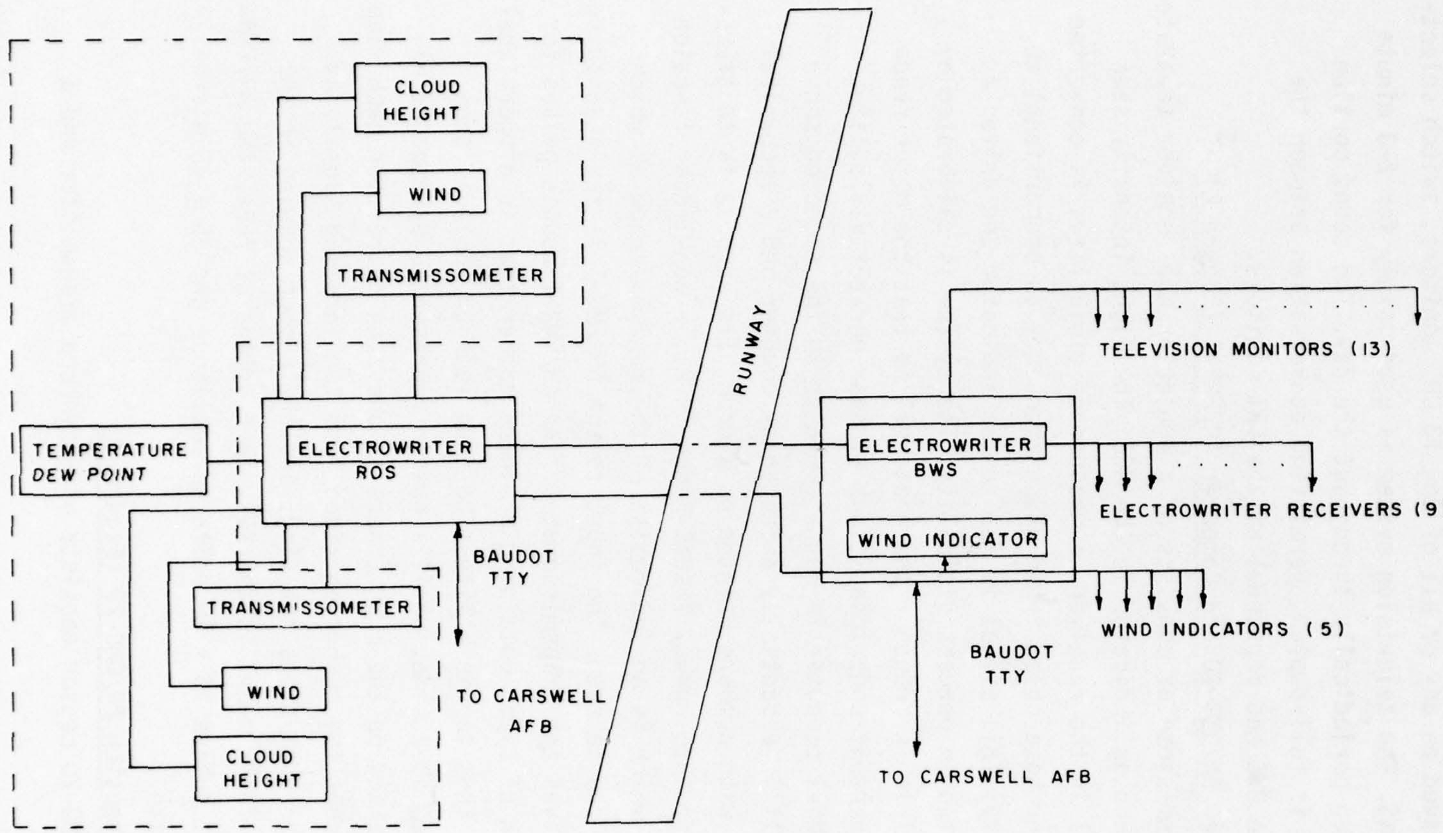

CLOUD HEIGHT
WIND
TRANSMISSOMETER
TEMPERATURE DEW POINT
ELECTROWRITER ROS
TRANSMISSOMETER
WIND
CLOUD HEIGHT
BAUDOT TTY
TO CARSWELL AFB
RUNWAY
ELECTROWRITER BWS
WIND INDICATOR
TELEVISION MONITORS (13)
ELECTROWRITER RECEIVERS (9)
WIND INDICATORS (5)
BAUDOT TTY
TO CARSWELL AFB

Figure 1

BWS are displayed on any or all of the 13 CRT monitors, switch selectable at the BWS. The television system is used mainly for 2-3 minute briefings given periodically throughout the day. The sound portion of the system is full-duplex, permitting conversation between the briefer at the BWS and personnel at the CRT monitors.

2.1 Transmissometer AN/GMQ-10 and Computer AN/FMN-1 (Figure 2)[2,3]

The transmissometer consists of a projector and receiver separated by 500 feet, and an indicator in the ROS. The light intensity seen by a photocell in the receiver, a measure of visibility, is converted in the receiver to a pulse train whose frequency is proportional to light intensity. This signal is fed to the indicator and drives a meter calibrated in percent visibility. The system is calibrated by adjusting an iris in front of the photocell so that the meter reads close to 100 percent under conditions of near perfect visibility.

The AN/FMN-1 computer is not a computer in the accepted sense of the term. It is essentially a frequency counter and a mechanical look-up table with numbers printed on a drum. Its purpose is to translate visibility into Runway Visual Range (RVR), a non-linear function of visibility which is an indication of the maximum range at which runway lights can be seen. The input to the AN/FMN-1 is the same pulse train that drives the transmissometer. The AN/FMN-1 counts pulses for a fixed length of time, obtaining a binary number that is proportional to frequency, thus to visibility. The drum look-up table is then rotated, a step at a time, until a number represented by conductive material deposited on the drum (there is one such number for each step position) matches the number obtained from the incoming signal. At this point, the drum stops rotating, and the number showing in the window on the front panel is the RVR, in hundreds of feet. The AN/FMN-1 requires input pulses 15 $\pm$ 10 volts in amplitude and 35 $\pm$ 15 microseconds in width.

2.2 Wind Speed/Direction AN/GMQ-20 (Figure 3)[4]

The AN/GMQ-20 sensor consists of a synchro transmitter and a

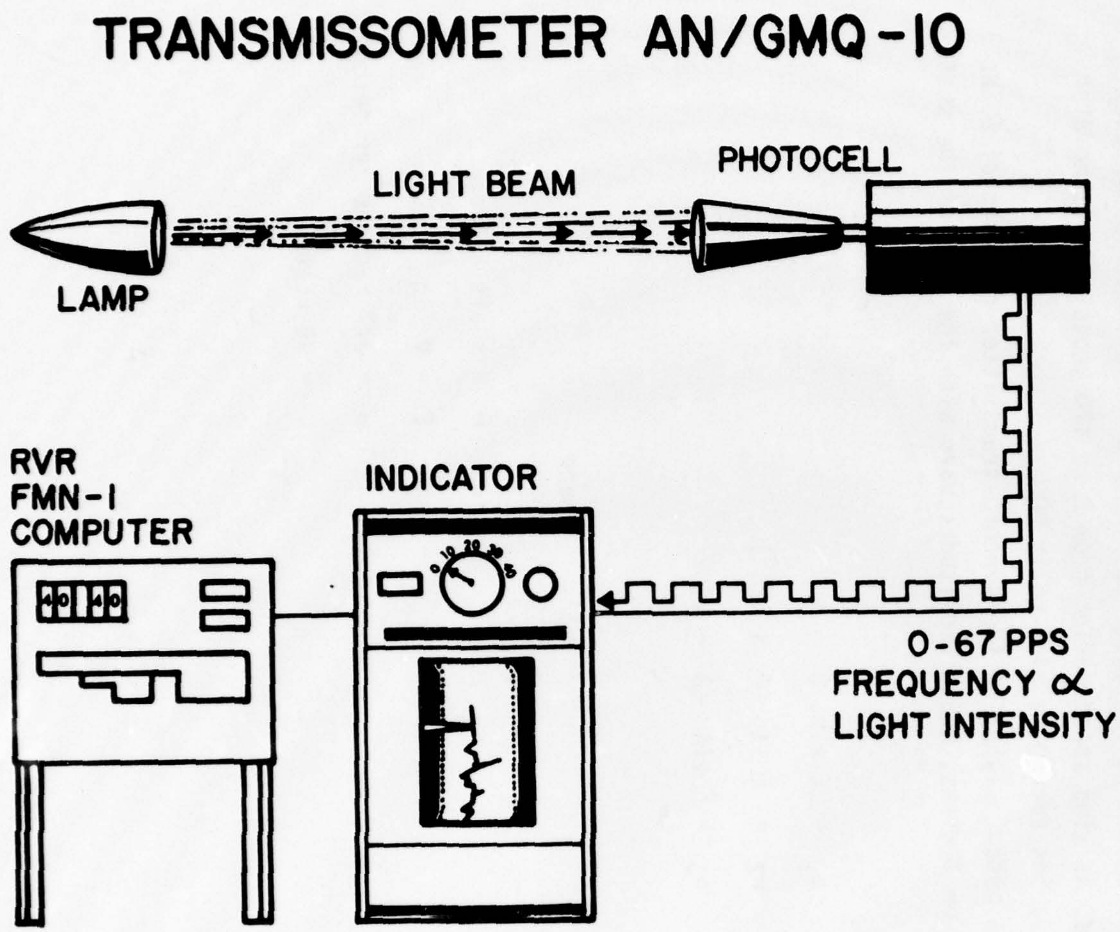

TRANSMISSOMETER AN/GMQ-10
LIGHT BEAM
PHOTOCELL
LAMP
RVR
FMN-1
COMPUTER
INDICATOR
0-67 PPS
FREQUENCY ∝
LIGHT INTENSITY

Figure 2

propeller-driven tachometer housed in a weather van.

The angular velocity of the propellor shaft, and in turn the DC voltage generated by the tachometer, is directly proportional to the wind speed. The indicator is simply a DC voltmeter calibrated in knots. As wind speed varies from 0 to 120 knots, the tachometer output varies from 0 to 14.7 volts DC.

The output signal of the synchro transmitter consists of 60 Hz signals on 3 wires, whose amplitudes vary with the sine of the shaft angle.

$$e_1 = E \sin \theta$$

$$e_2 = E \sin (\theta + 120^{o})$$

$$e_3 = E \sin (\theta + 240^{o})$$

where

θ = shaft angle

$E = V \sin wt$

w = 377 radians per second

V = 90 volts

WIND SPEED / DIRECTION AN/GMQ-20

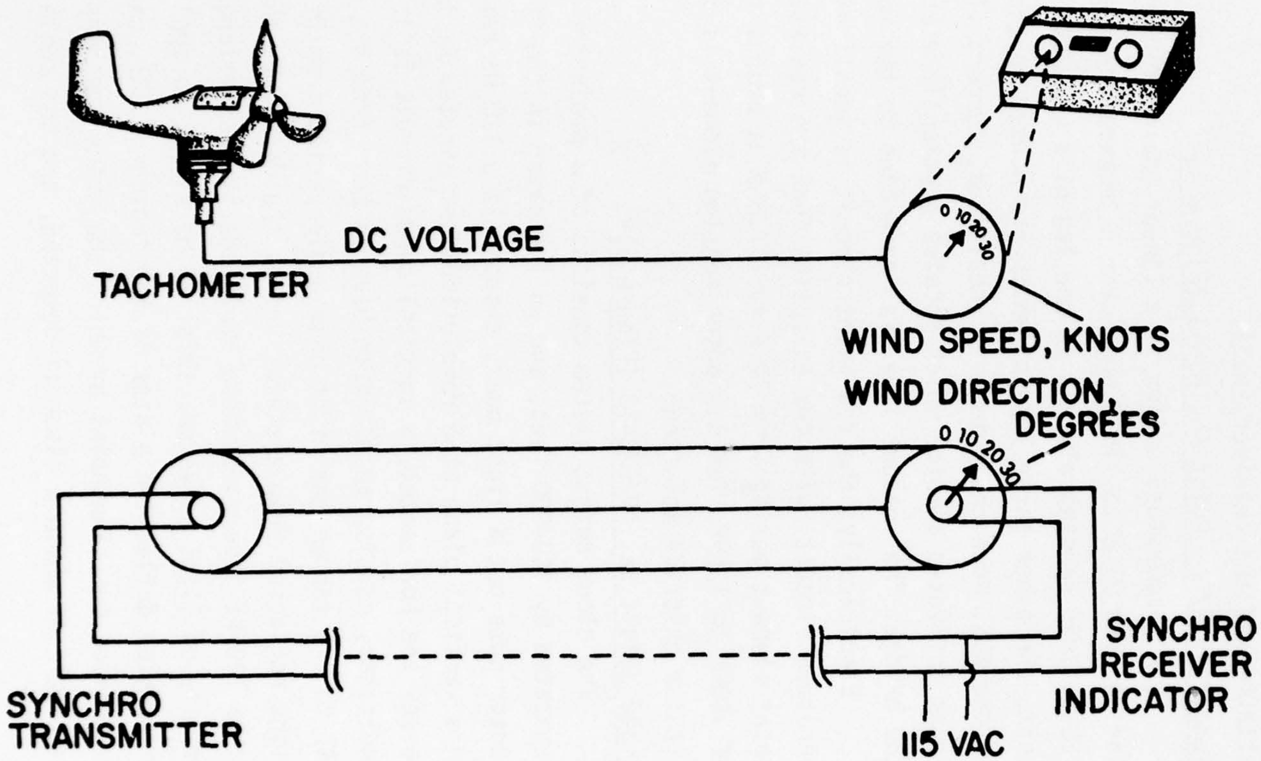


Figure 3

The synchro receiver is a unit similar to the transmitter, whose shaft is forced by the 60 Hz signals on the three lines to assume the same angular position as the transmitter shaft. The readout is a pointer attached to the receiver shaft.

2.3 Temperature/Dew Point AN/TMQ-11 (Figure 4) [5]

The temperature sensor is a linear thermistor whose resistance varies from 77.6 to 119.6 ohms over a temperature range of -80°F to 130°F. This sensing element is one leg of a wheatstone bridge circuit, the other three legs of which are housed in the indicator unit at the ROS. When the bridge is unbalanced, current flow through a meter activates a motor which rotates a potentiometer to balance the bridge. The readout is a dial connected to the motor shaft.

Electrically, the dew point circuit is identical to the temperature circuit, with the exception that the resistance of the dew point element varies from 77.6 to 117.6 ohms over a temperature range of -80°F to 120°F. The dew point sensing element is surrounded by a lithium chloride solution.

2.4 Cloud Height Set AN/GMQ-13 (Figure 5)[6]

The cloud height system consists of a projector and detector separated by 400-900 feet, and an indicator in the ROS. The projector puts out a light beam, chopped at a 120 Hz rate, rotating in a vertical plane at 5 revolutions per minute. As the light beam passes the horizontal, a vertical sweep circuit is triggered in the indicator, causing an electron beam to move from the bottom of a CRT to the top as the light beam angle varies from 0° to 90°. When light reflected from a cloud strikes the detector, the detector puts out a 120 Hz sine wave whose amplitude is proportional to the intensity of light detected. This 120 Hz signal is applied to the horizontal deflection plates of the indicator CRT, causing the trace to broaden out. The point at which the trace broadens out thus gives the angle at which a cloud is detected, and the angle is translated

TEMPERATURE / DEW POINT SET AN/TMQ-11

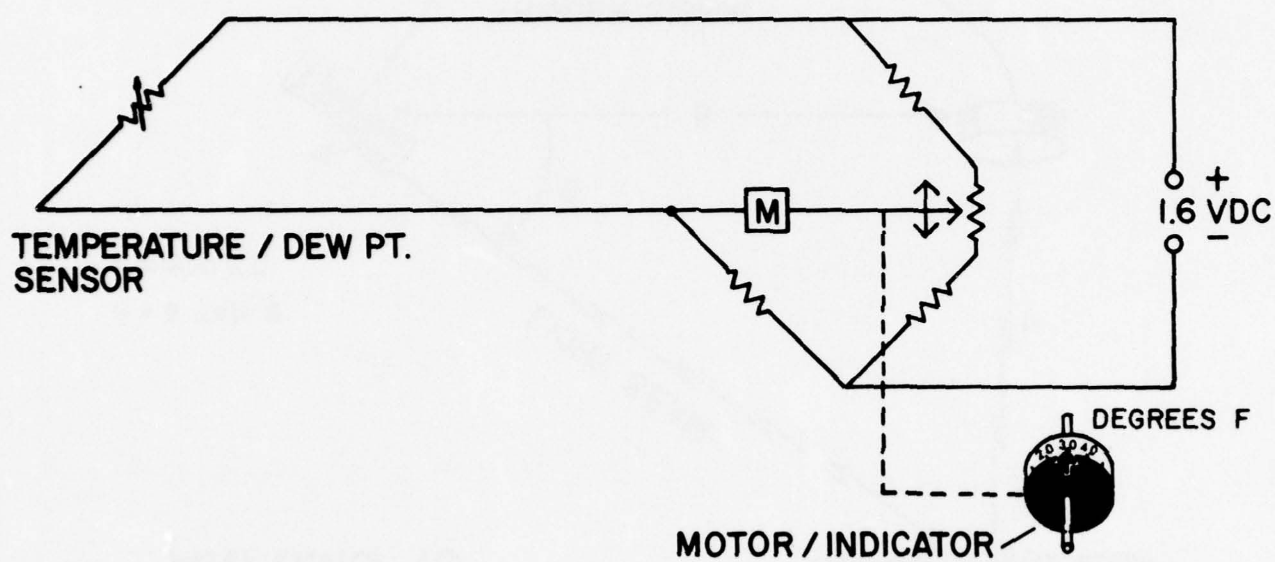


Figure 4

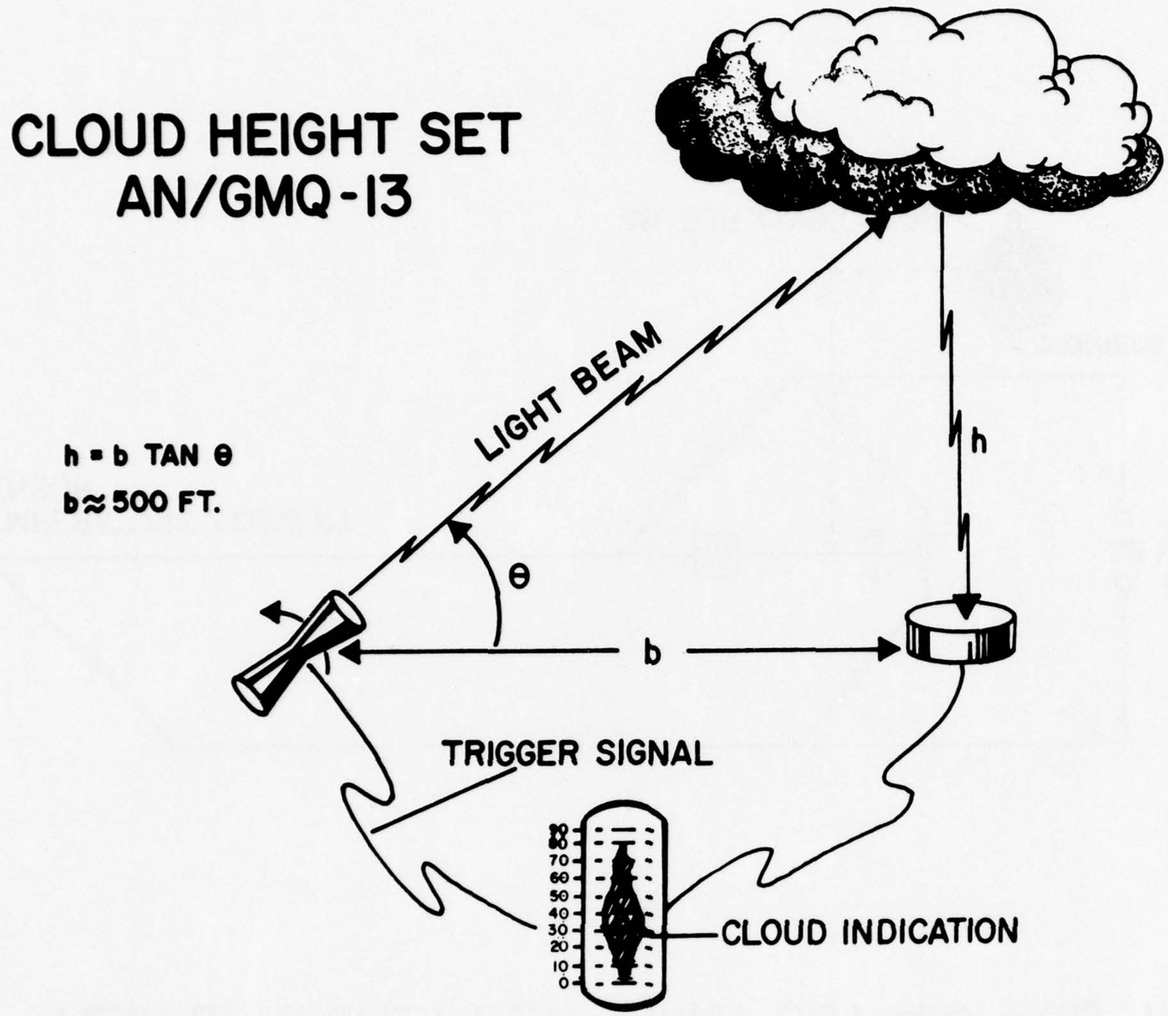

CLOUD HEIGHT SET
AN/GMQ-13
h = b TAN θ
b ≈ 500 FT.
LIGHT BEAM
θ
b
h
TRIGGER SIGNAL
CLOUD INDICATION
90
80
70
60
50
40
30
20
10
0

Figure 5

to cloud height by the formula $h = b \tan \theta$ where h = cloud height in feet, b = baseline in feet. This translation is performed by a human operator who looks up the cloud height in a table.

2.5 Deficiencies

(1) Time Delays: The time lag from the instant a weather sensor detects a change to the instant the key air traffic controller is informed of it (via the electrowriter) can be as great as ten minutes. Dissemination of weather data to the outside world must wait until the ROS observer has punched an accurate paper tape on a teletypewriter.

(2) Erroneous Data: It is possible for the ROS observer to make mistakes in preparing paper tapes, and the writing on an electrowriter receiver is often illegible (nines are read as zeros, etc.).

(3) The ROS is expensive to maintain, since it requires sanitary facilities, heat and back-up power.

(4) The ROS is crowded, since it houses several large indicators. Lack of space makes operation and maintenance difficult.

(5) Cable Maintenance and Replacement Costs: The meterological cable connecting sensors and indicators requires frequent trouble-shooting and repair, mainly due to the fact that the cable generally carries analog data. In an analog system, information is contained in the amplitude of the signal, which is highly sensitive to changes in cable parameters.

3. APPROACHES TO DIGITIZATION AND DISSEMINATION

THE RADC FEASIBILITY MODEL

It now appears possible to eliminate most of the present system's shortcomings by performing A/D conversion at each sensor, doing away with the ROS, and installing a control and dissemination unit at the BWS. To examine methods for accomplishing this, the RADC feasibility model was developed.

3.1 Control and Processing Unit - Block Diagram Analysis (Figure 6).

The control and Processing unit is built around the INTEL Corporation Intellec 8 microprocessor development system with a model 8080 CPU. A 70-pin cable from the interface card slot of the Intellec 8 connects to the interface card file which houses the logic to accept and condition data from all sensors in the system. The circuitry for each sensor is mounted on its own 4" x 5" card, providing a high degree of modularity at the cost of some extra components. These interface modules receive their data over twisted pairs from the data transmitters colocated with the sensors.

3.1.1 Wind Interface

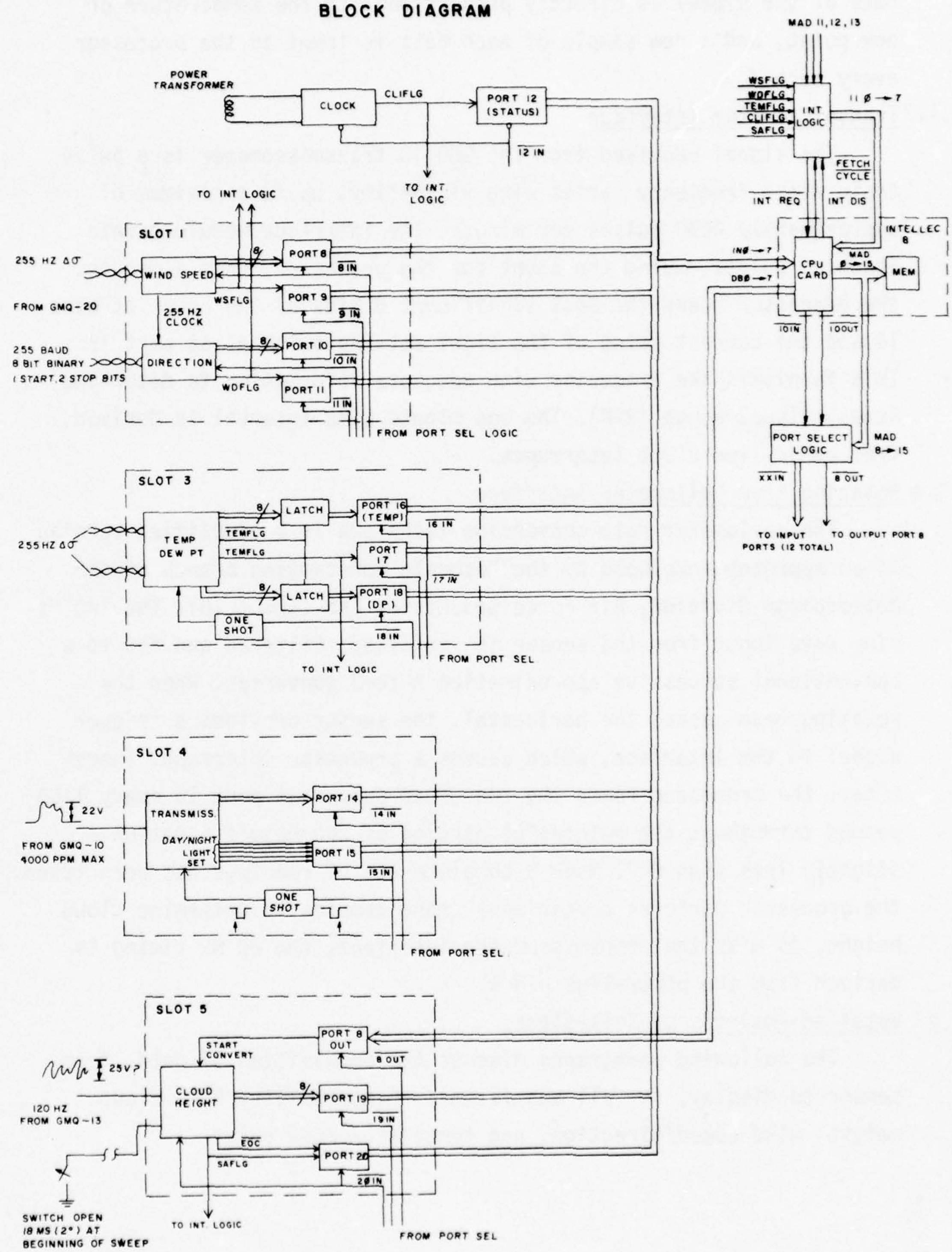
The wind speed signal appears at the interface module as a delta-sigma modulated bit stream, which can be treated as repetition rate modulation with a maximum frequency of 255 Hz. The interface module counts incoming pulses for one second, then interrupts the processor and sets a flag (one bit of port 9) by raising WSF. The processor reads the accumulated count from port 8, automatically resetting the flag and clearing the count, and the process is allowed to repeat.

The wind direction signal is a continuous stream of 8 bit binary numbers each representing an instantaneous value of wind direction, each having its own start and stop bits. The data rate is 255 bits per second. Each time the interface module has received a complete 8 bit byte with stop bits, it interrupts the processor and sets one bit of port 11 as status flag by raising WDF. The processor then reads the data byte from port 10, resetting the flag. Thus, the processor receives approximately 25 samples of wind direction data per second.

3.1.2 Temperature/Dew Point Interface

The temperature/dew point signals received are identical to the wind speed signals and are handled in the same way. The repetition

Fig. 6 – CONTROL & PROCESSING UNIT BLOCK DIAGRAM



rate of the signal is directly proportional to the temperature or dew point, and a new sample of each data is input to the processor every second.

3.1.3 Transmissometer Interface

The signal received from the GMQ-10 transmissometer is a pulse train whose frequency varies with visibility, up to a maximum of approximately 4000 pulses per minute. The interface module counts incoming pulses, saving the count for the processor. Once a minute, the processor reads the most significant 8 bits of the count at port 14 and the current value of the light setting switches at port 15. This furnishes the processor with adequate information to determine Runway Visual Range (RVR). The one minute time interval is derived from power-line clock interrupts.

3.1.4 Rotating Beam Ceilometer Interface

The ceilometer data conversion technique is a simplified version of an approach developed by the Mesocale Forecasting Branch of the Meteorology Division, Air Force Geophysics Lab (AFGL/LYU). The 120 Hz sine wave input from the sensor is rectified, filtered and fed to a conventional successive approximation A-to-D converter. When the rotating beam passes the horizontal, the sensor provides a trigger signal to the interface, which causes a processor interrupt. Thereafter, the processor reads the converter output at port 19 every 1/60 second throughout the meaningful portion of the beam's rotation - slightly less than 90^{o}. When a complete set of readings has been taken, the processor performs comparisons among samples to determine cloud height. As with the transmissometer interface, the 60 Hz timing is derived from the power-line clock.

3.2 Detailed Analysis of Subsystems:

The following paragraphs discuss the acquisition of data, from sensor to display, for all subsystems: transmissivity/RVR, cloud height, wind speed/direction, and temperature/dew point.

3.2.1 Transmissivity/RVR

Figure 7 is a schematic diagram of the transmissometer interface module. In the feasibility model, no signal conditioning unit is added to the transmissometer. Rather, the signal normally fed to the indicator at the ROS is applied directly to the interface module, where the pulses are clipped and reshaped by Q_1 and U 1. If necessary or desirable in a future system, Q_1 and U 1 could be colocated with the transmissometer at the other end of the cable and followed by a line driver. Figure 7 shows the pulse at the input to the interface module as it appears on an oscilloscope. U 1, a non-retrigerable one shot, puts out a 100 ms pulse, insuring against counting an input pulse more than once due to the pronounced overshoot and ringing present. (See figure 8, transmissometer interface timing).

U - 2, 5 and 4 form a 12 bit counter, whose most significant 8 bits are fed to the processor's input port 14. Once per minute, the processor reads a byte of data from port 14 by placing a negative-going pulse on the 14IN port select line. The trailing edge of this pulse is fed to a one-shot (U 3) and used to clear the counters after the port has been read, preparing them to collect pulses for another one minute period. Since the maximum rate is 4000 pulses per minute (indicating maximum visibility), the highest possible count in the most significant 8 bits of the counter will be 250.

S1 through S4 perform the functions of the light setting switches on the FMN-1 computer and the day/night switch in the control tower. It will be seen from the transmissometer software flow chart (figure 9) and the program listing (figure 10) that the processor reads the switches at port 15 every time it reads a byte of visibility data from port 14, and uses the switch setting data to decide which look-up table to get runway visual range (RVR) from. For simplicity, the feasibility model uses 4 look-up tables, corresponding to 4 possible

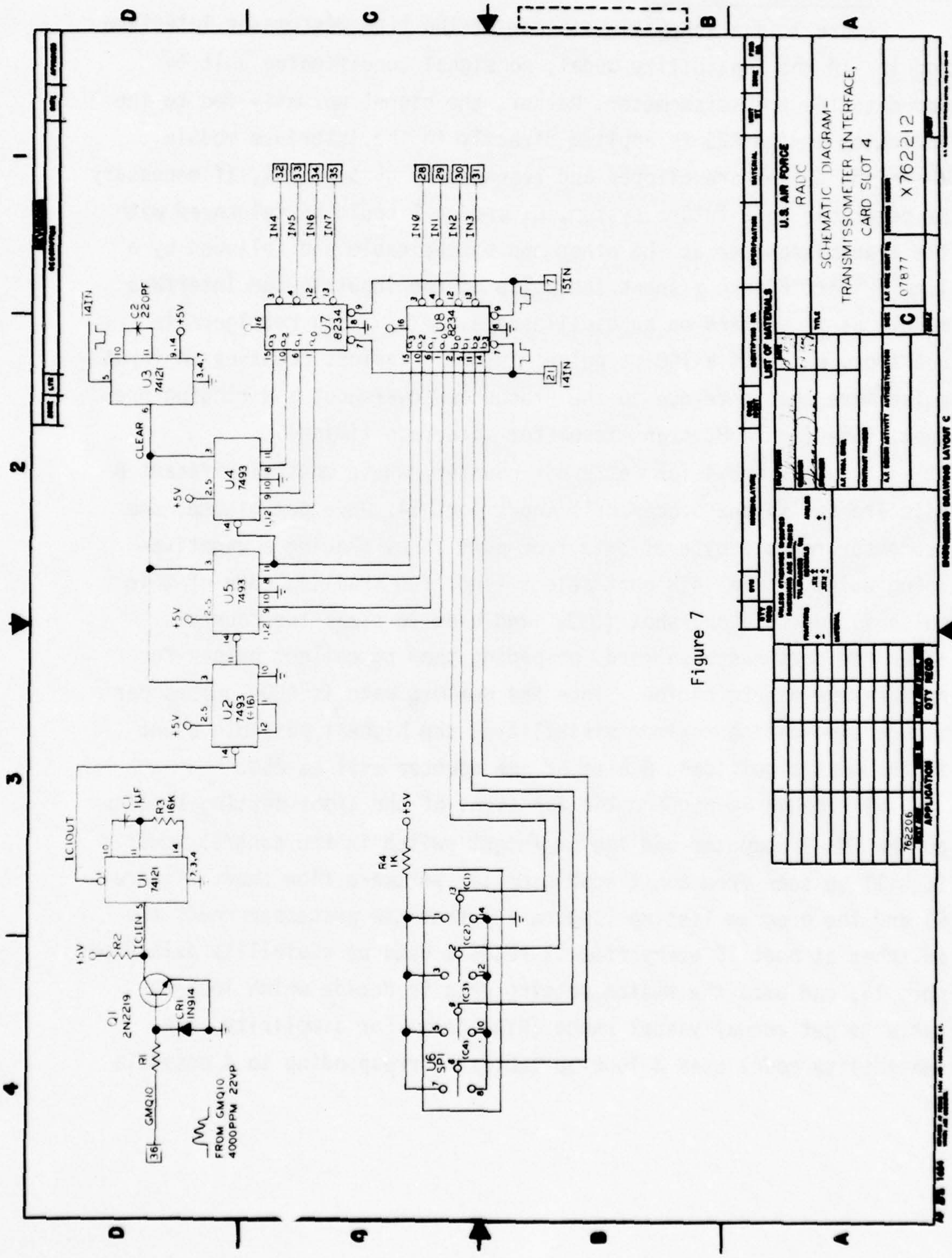

U.S. AIR FORCE
RADC
SCHEMATIC DIAGRAM-
TRANSMISSOMETER INTERFACE,
CARD SLOT 4
C
07877
X762212
LIST OF MATERIALS
APPLICATION
762206
QTY REQD
U1
74121
U2
7493
U3
74121
U4
7493
U5
7493
U7
8234
U8
8234
U6
SP1
Q1
2N2219
CR1
IN914
C1
1µF
R3
16K
C2
220PF
R4
1K
+5V
CLEAR
ICIOUT
GMQ10
FROM GMQ10
4000PPM 22VP
IN0
IN1
IN2
IN3
IN4
IN5
IN6
IN7
14IN
15IN

Figure 7

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED

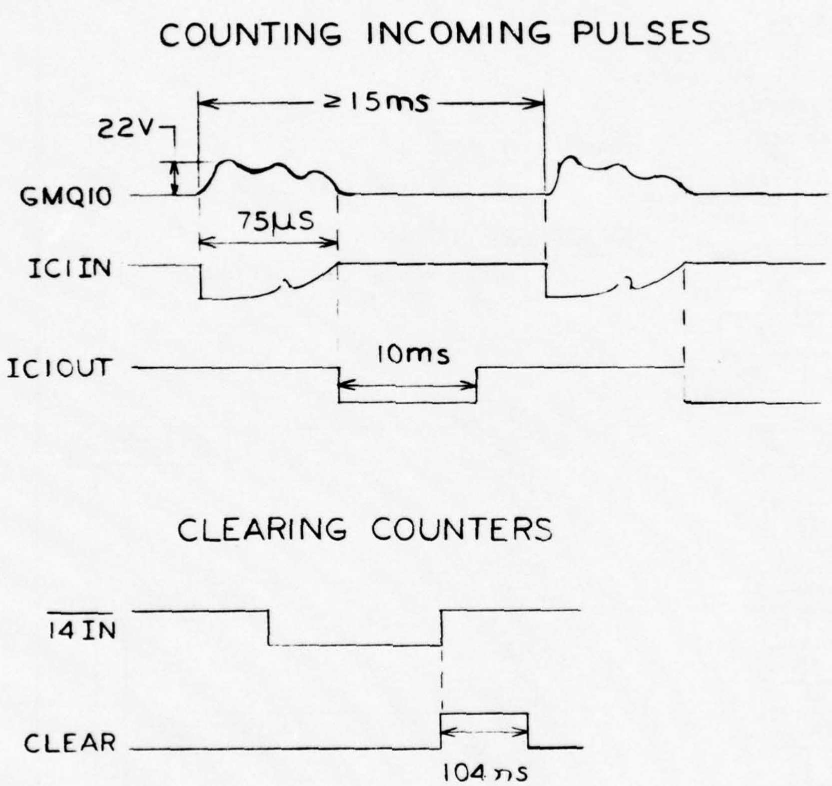


FIGURE 8

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± DECIMALS XX ± XXX ± ANGLES ±

MATERIAL

DRAFTSMAN / DATE

CHECKER

ENGINEER

A.F. PROJ. ENGR.

CONTRACT NO.

A.F. DESIGN ACTIVITY AUTHENTICATION

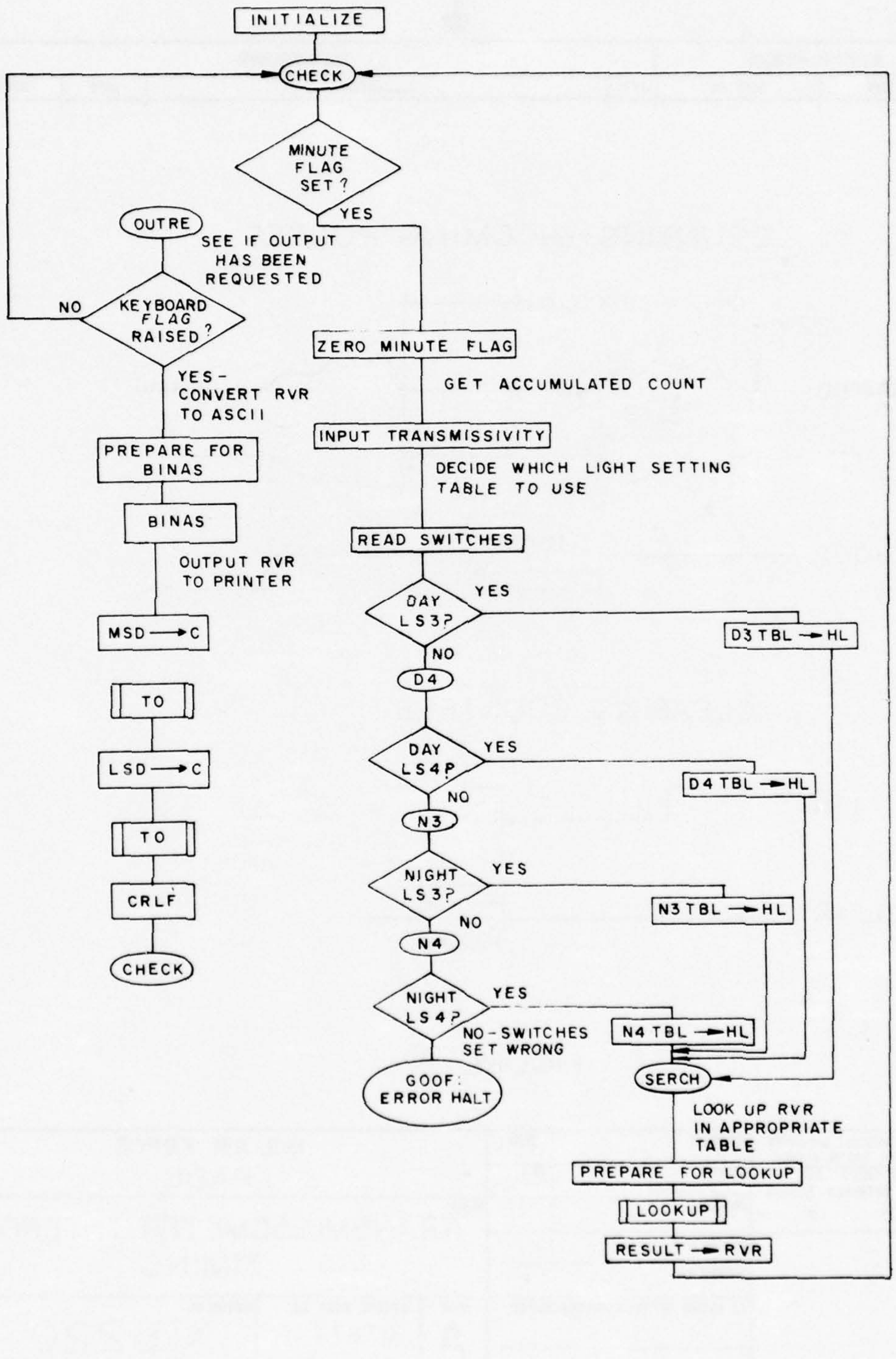
D/L 762206

U.S. AIR FORCE
RADC

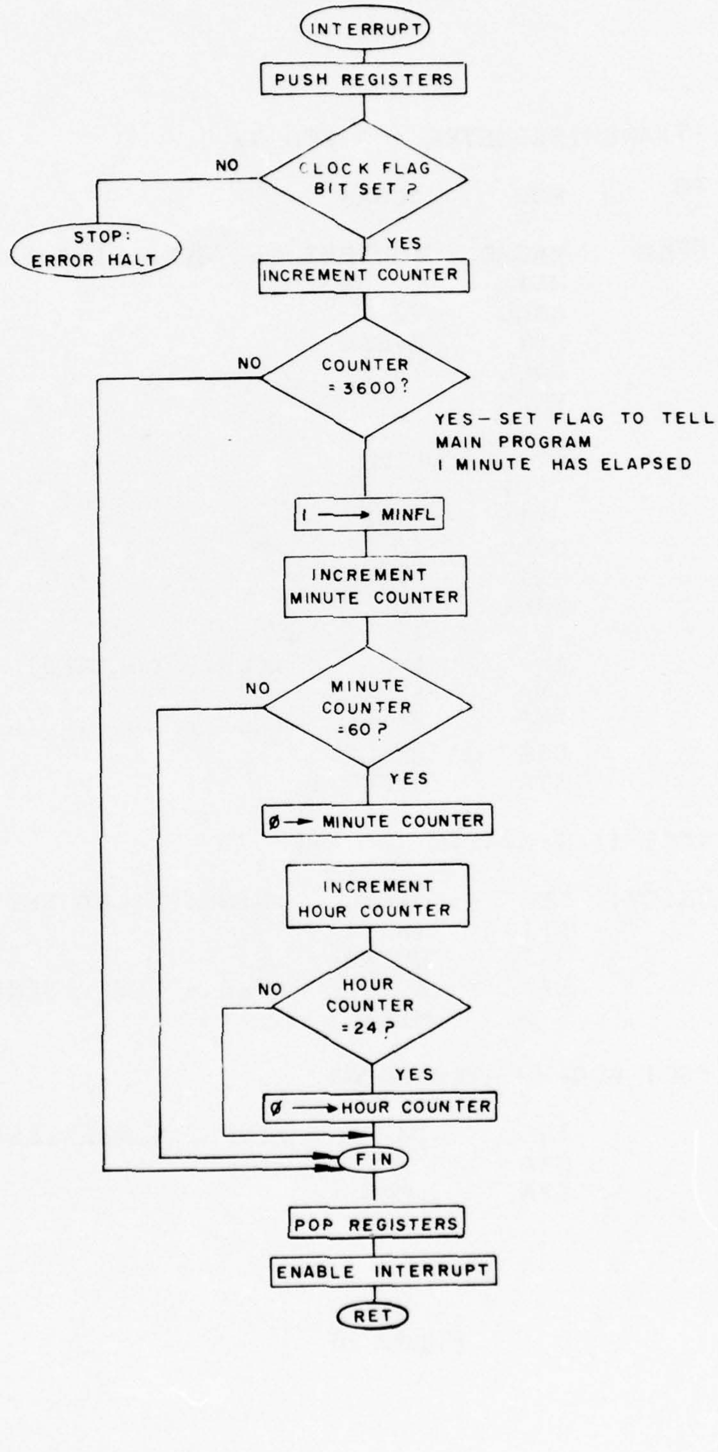
TITLE
TRANSMISSOMETER INTERFACE TIMING

SIZE	A.F. CODE IDENT NO.	DRAWING NO.
A	07877	X762207
SCALE		SHEET

TRANSMISSOMETER FLOW CHART
Fig. 9



SERVICE CLOCK PULSE INTERRUPT



```
                    ;TRANSMISSOMETER - 3 FEB 76

3C3A                TO       EQU      3C3AH

                    CRLF     MACRO    ;OUTPUT CAR RET, LINE FEED
                             MVI      C,0DH
                             CALL     TO
                             MVI      C,0AH
                             CALL     TO
                             ENDM

0000                         ORG      400H
                             CRLF
0400 0E0D                    MVI      C,0DH
0402 CD3A3C                  CALL     TO
0405 0E0A                    MVI      C,0AH
0407 CD3A3C                  CALL     TO

040A DB0E                    IN       14        ;CLEAR COUNTER
040C AF                      XRA      A
040D 327300                  STA      MINFL     ;CLEAR MINUTE FLAG & COUNTER
0410 327600                  STA      BINCT
0413 327700                  STA      BINCT+1

                    ;SEE IF 1 MINUTE HAS ELAPSED

0416 3A7300         CHECK:   LDA      MINFL     ;MINUTE FLAG SET?
0419 FE01                    CPI      1H
041B C26A04                  JNZ      OUTRE
041E AF                      XRA      A         ;YES - RESET MINUTE FLAG
041F 327300                  STA      MINFL

                    ;GET ACCUMULATED COUNT

0422 DB0E                    IN       14        ;INPUT TRANSMISSIVITY
0424 2F                      CMA
0425 327800                  STA      TRANS
```

Figure 10

BEST AVAILABLE COPY

```
                    ;DECIDE WHICH LIGHT SETTING TABLE TO USE

0428 DB0F                   IN      15      ;READ LIGHT SETTING SWITCHES
042A FE00                   CPI     0H      ;DAY LS 3?
042C C23504                 JNZ     D4
042F 217900                 LXI     H,D3TBL ;PREPARE TO SEARCH DAY 3 TABLE
0432 C35704                 JMP     SERCH
0435 FE01           D4:     CPI     01H     ;DAY LS 4?
0437 C24004                 JNZ     N3
043A 217F00                 LXI     H,D4TBL
043D C35704                 JMP     SERCH
0440 FE08           N3:     CPI     08H     ;NIGHT LS 3?
0442 C24B04                 JNZ     N4
0445 218500                 LXI     H,N3TBL
0448 C35704                 JMP     SERCH
044B FE09           N4:     CPI     09H     ;NIGHT LS 4?
044D C25604                 JNZ     GOOF
0450 218B00                 LXI     H,N4TBL
0453 C35704                 JMP     SERCH
0456 76             GOOF:   HLT             ;SWITCHES SET WRONG

                    ;LOOK UP RVR IN APPROPRIATE TABLE

0457 3A9700         SERCH:  LDA     LNGTH   ;PREPARE TO LOOK UP RVR
045A 47                     MOV     B,A
045B 3A7800                 LDA     TRANS
045E 119100                 LXI     D,OUTLS
0461 CD9504                 CALL    LOOKP
0464 329800                 STA     RVR
0467 C31604                 JMP     CHECK

                    ;SEE IF OUTPUT HAS BEEN REQUESTED

046A DB01           OUTRE:  IN      1       ;OUTPUT REQUEST?
046C E601                   ANI     1H
046E C21604                 JNZ     CHECK
0471 DB00                   IN      0       ;YES - CLEAR TTY FLAG

                    ;CONVERT RVR TO ASCII

0473 3A9800                 LDA     RVR     ;PREPARE TO CONVERT TO ASCII
0476 219900                 LXI     H,BFR
0479 CDA604                 CALL    BINAS
```

```
                  ;OUTPUT RVR TO PRINTER

047C 219A00              LXI     H,BFR+1 ;OUTPUT 2 DIGITS
047F 4E                  MOV     C,M
0480 CD3A3C              CALL    TO
0483 23                  INX     H
0484 4E                  MOV     C,M
0485 CD3A3C              CALL    TO
                         CRLF
0488 0E0D                MVI     C,0DH
048A CD3A3C              CALL    TO
048D 0E0A                MVI     C,0AH
048F CD3A3C              CALL    TO

0492 C31604              JMP     CHECK

0495 BE         LOOKP:   CMP     M       ;LOOK UP RVR IN TABLE
0496 DAA304              JC      MATCH
0499 05                  DCR     B
049A C29E04              JNZ     NOTFN
049D 76                  HLT             ;NO MATCH FOUND
049E 23         NOTFN:   INX     H
049F 13                  INX     D
04A0 C39504              JMP     LOOKP
04A3 EB         MATCH:   XCHG
04A4 7E                  MOV     A,M
04A5 C9                  RET



04A6 0664       BINAS:   MVI     B,100
04A8 CDB604              CALL    DIGIT
04AB 060A                MVI     B,10
04AD CDB604              CALL    DIGIT
04B0 0601                MVI     B,1
04B2 CDB604              CALL    DIGIT
04B5 C9                  RET
04B6 3630       DIGIT:   MVI     M,30H
04B8 90         DI0:     SUB     B
04B9 DAC004              JC      DI1
04BC 34                  INR     M
04BD C3B804              JMP     DI0
04C0 80         DI1:     ADD     B
04C1 23                  INX     H
04C2 C9                  RET
```

```
                         ;SERVICE CLOCK PULSE INTERRUPT

04C3                  ORG    28H       ;COUNT A 60 HZ CLOCK PULSE
0028 C5               PUSH   B         ;ON INTERRUPT
0029 D5               PUSH   D
002A E5               PUSH   H
002B F5               PUSH   PSW
002C DB0C             IN     12
002E E601             ANI    01H       ;CLOCK  BIT SET?
0030 C27200           JNZ    STOP      ;NO - CHECK OTHER FLAGS
0033 2A7600           LHLD   BINCT     ;YES - INCR BINARY COUNTER
0036 23               INX    H
0037 227600           SHLD   BINCT
003A 217600           LXI    H,BINCT   ;COUNTER = 3600?
003D 7E               MOV    A,M       ;LSB
003E FE10             CPI    10H
0040 C26C00           JNZ    FIN
0043 23               INX    H         ;MSB
0044 7E               MOV    A,M
0045 FE0E             CPI    0EH
0047 C26C00           JNZ    FIN
004A 3600             MVI    M,0H      ;COUNTER = 3600 - 0 COUNTER
004C 2B               DCX    H
004D 3600             MVI    M,0H
004F 217300           LXI    H,MINFL   ;SET MINUTE FLAG
0052 3601             MVI    M,1H
0054 217500           LXI    H,MIN     ;INCR 24 HOUR CLOCK
0057 34               INR    M
0058 7E               MOV    A,M
0059 FE3C             CPI    60        ;MIN = 60?
005B C26C00           JNZ    FIN
005E 3600             MVI    M,0       ;YES - 0 MIN
0060 217400           LXI    H,HOUR
0063 34               INR    M
0064 7E               MOV    A,M
0065 FE18             CPI    24        ;HOUR = 24?
0067 C26C00           JNZ    FIN
006A 3600             MVI    M,0       ;YES - 0 HOUR
006C F1       FIN:    POP    PSW
006D E1               POP    H
006E D1               POP    D
006F C1               POP    B
0070 FB               EI
0071 C9               RET
0072 76       STOP:   HLT
```

```
0073                MINFL:  DS       1
0074                HOUR:   DS       1
0075                MIN:    DS       1
0076                PINCT:  DS       2

0078                TRANS:  DS       1
0079 437598AC D3TBL:  DB       67,117,152,172,198,250
007D C6FA
007F 2C7598AC D4TBL:  DB       44,117,152,172,198,250
0083 C6FA
0085 05245275 N3TBL:  DB       5,36,82,117,168,250
0089 A8FA
008B 03183E5F N4TBL:  DB       3,24,62,95,143,250
008F 94FA
0091 000E1822 OUTLS:  DB       0,14,24,34,50,99
0095 3263
0097 06       LNGTH:  DB       6        ;LENGTH OF CHECK LIST
0098                RVR:    DS       1
0099                BFR:    DS       3
0000                        END
```

P=

switch settings. Each table has only 6 entries. In an operational system, there would be 6 tables with 20 entries each. The feasibility model processor is programmed to interpret the switch settings according to table 1.

S1	S2	S3	S4	Light Setting	Day/Night
0	0	0	0	3	Day
0	0	0	1	4	Day
1	0	0	0	3	Night
1	0	0	1	4	Night

Table 1, Interpretation of Switch Settings

The one minute time interval for the transmissometer interface module is derived in software from the power line clock of figure 11. The 60 Hz signal on the secondary winding of the system's 12 volt power supply is shaped into a square wave by Q_1 and IC. The leading edge of the square wave sets D flipflop IC 2, raising CLIFLG to interrupt the processor. Upon recognizing the interrupt, the processor reads port 12, which also clears the D flipflop. As shown in the flow chart, figure 9, the processor increments a counter in memory every time it is interrupted by a clock pulse, and sets a "minute flag" when the count has reached 3600, indicating that one minute has elapsed. Similarly, the clock keeps track of real time in hours and minutes. While this feature is not used by the transmissometer routine, it is useful for such purposes as automatically appending real time to messages.

In the absence of interrupts, the main transmissometer routine continuously checks the minute flag and the keyboard flag (discussed below). Upon finding the minute flag set the processor reads the visibility and switch settings from ports 14 and 15, and immediately looks up the RVR in the appropriate table, each 8-bit entry of which

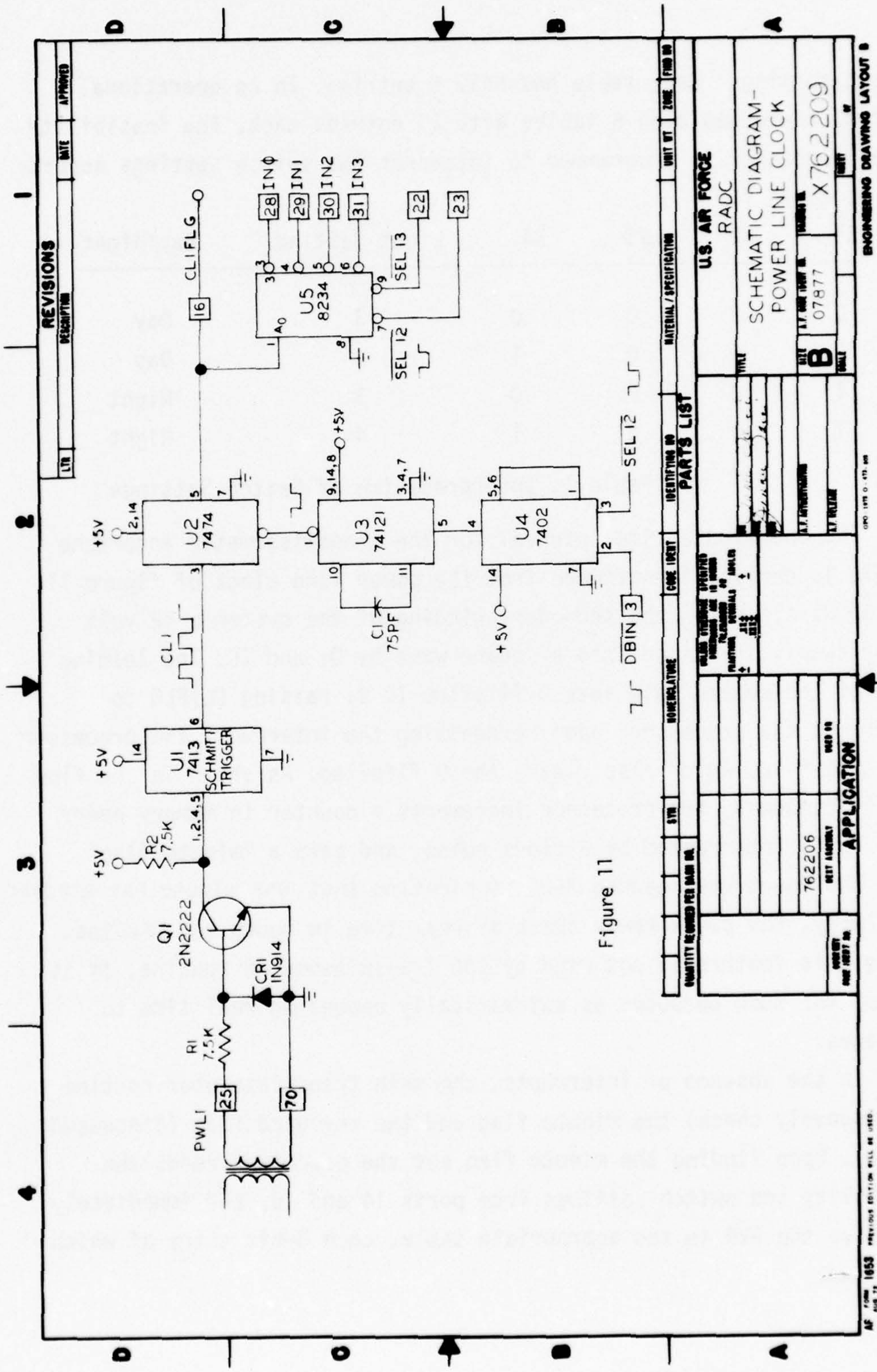

REVISIONS
PWL1
R1 7.5K
CR1 1N914
Q1 2N2222
R2 7.5K
U1 7413 SCHMITT TRIGGER
CL1
C1 75PF
U2 7474
U3 74121
U4 7402
U5 8234
CL1FLG
DBIN
SEL 12
SEL 13
IN0
IN1
IN2
IN3
PARTS LIST
APPLICATION
762206
U.S. AIR FORCE
RADC
SCHEMATIC DIAGRAM-
POWER LINE CLOCK
07877
X762209
ENGINEERING DRAWING LAYOUT B

Figure 11

is an actual RVR value, in hundreds of feet. This value is then moved to buffer location "RVR" until it is retrieved for display.

The display used in the feasibility model is the page printer of the teletypewriter console, and output to the printer is initiated by depressing any key on the keyboard, raising the keyboard flag. When the processor finds the keyboard flag set, it retrieves the RVR from the buffer, converts it to ASCII via sub-routine "BINAS" and outputs the results to the printer.

3.2.2 Cloud Height

Figure 12 is a schematic diagram of the cloud height interface module. As the ceilometer beam passes the horizontal, the sync switch located in the RBC opens for approximately 18 ms, raising SAF and causing an interrupt, which tells the processor to take a reading from the A/D converter for each of the next 180 real time cloud interupts. Thereafter, each time a real time clock interrupt occurs the processor provides a "start convert" signal to the A/D converter by outputting a "one" on output port 8, then waits to read the cloud height data until "end of convert" (EOC) is turned on by the converter. After all 180 readings have been taken and saved, the list of readings is examined to find the largest. From its position in the list, cloud height can be obtained by going to a look-up table similar to that used to determine RVR.

3.2.3 Wind Speed and Direction

Figure 13 is a schematic diagram of the wind speed and direction transmitter, colocated with the sensor. The RC clock (U 3) provides 225 Hz clock signals for both the speed and direction sections. Due to the clock signal reconstruction technique used at the receiver (figure 14), clock accuracy and stability is not critical. The output of the wind direction sensor (90 volt line-to-line synchro transmitter) is fed to a modular synchro-to-digital converter, the Astrosystems

BEST AVAILABLE COPY

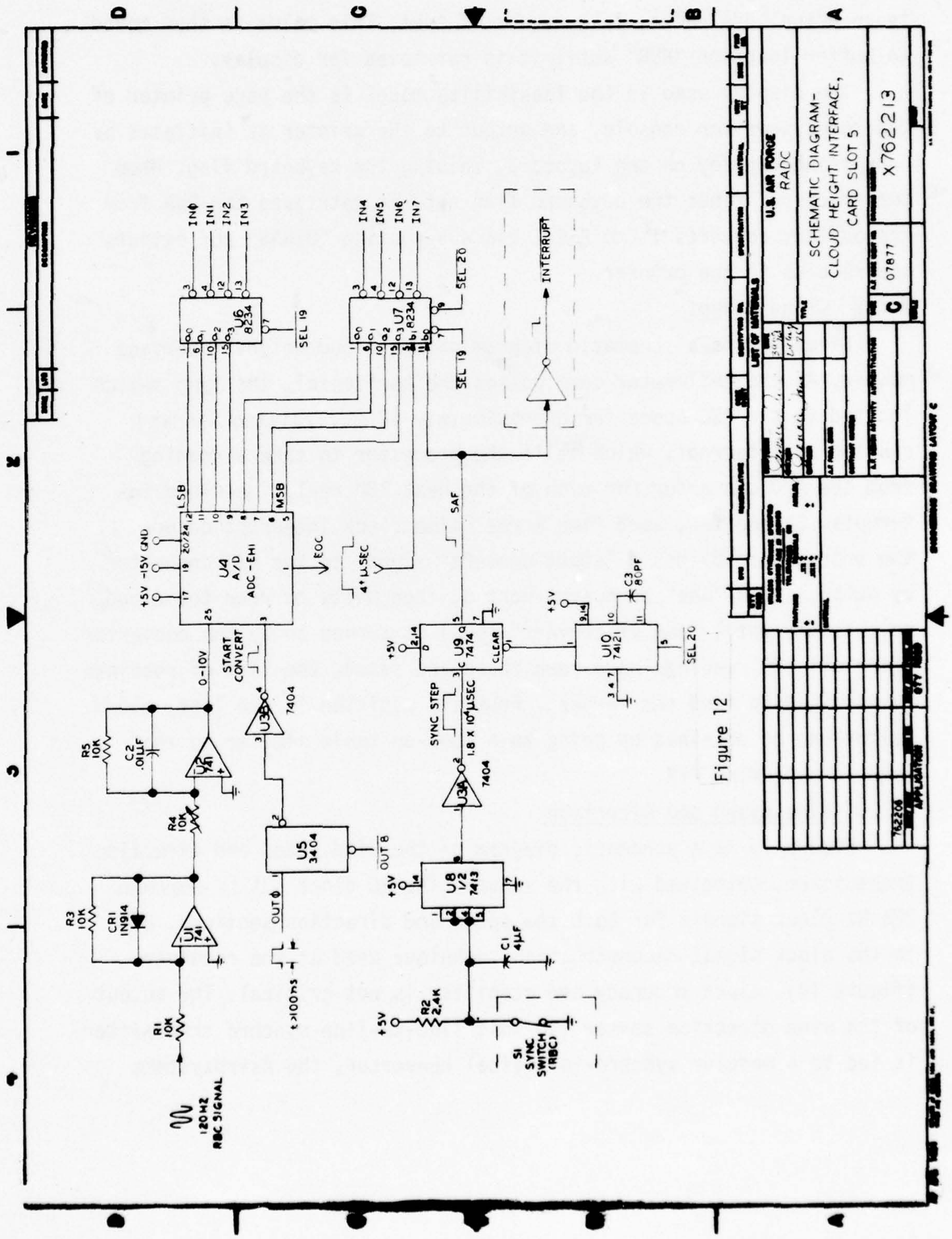


Figure 12

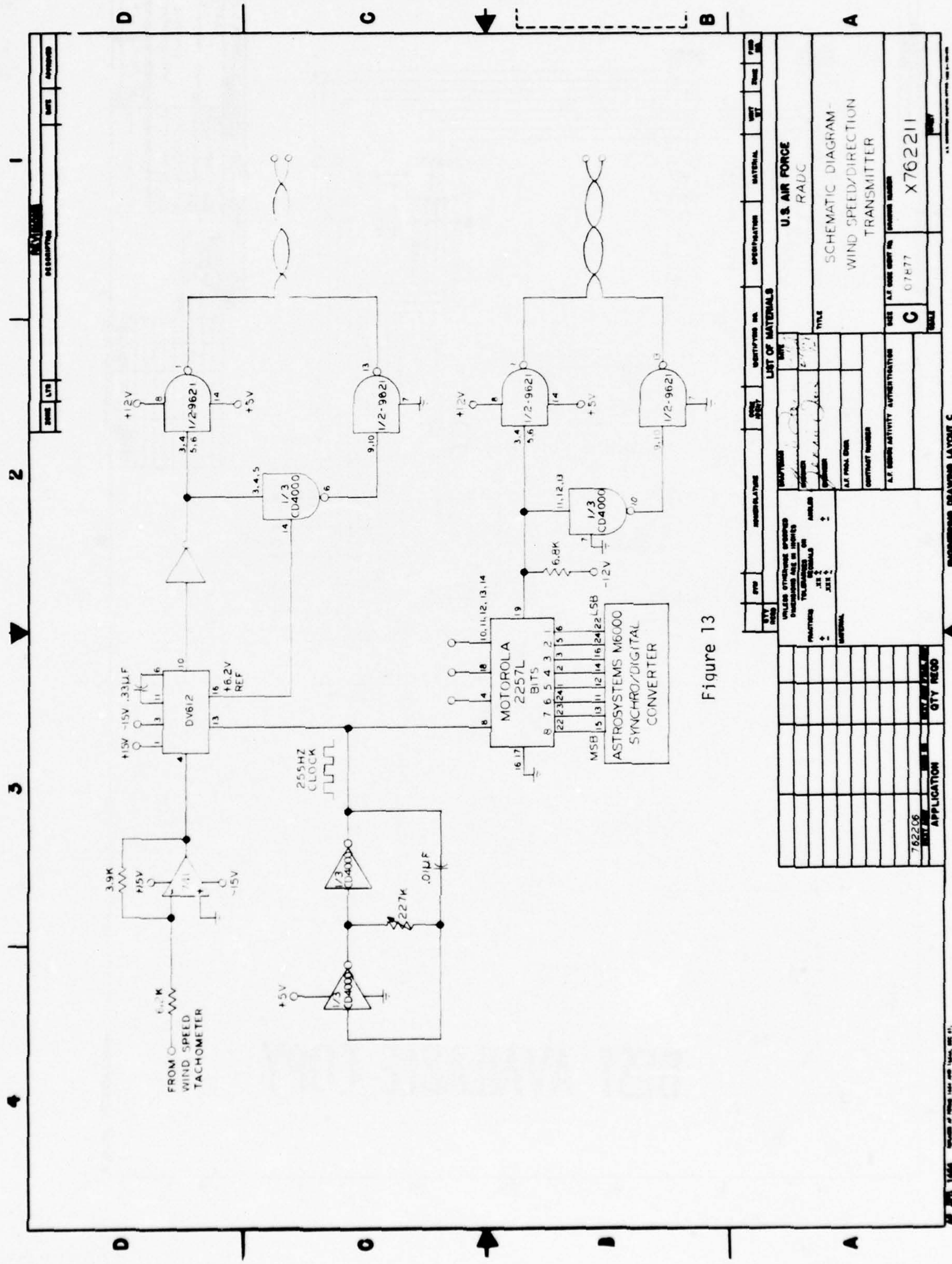
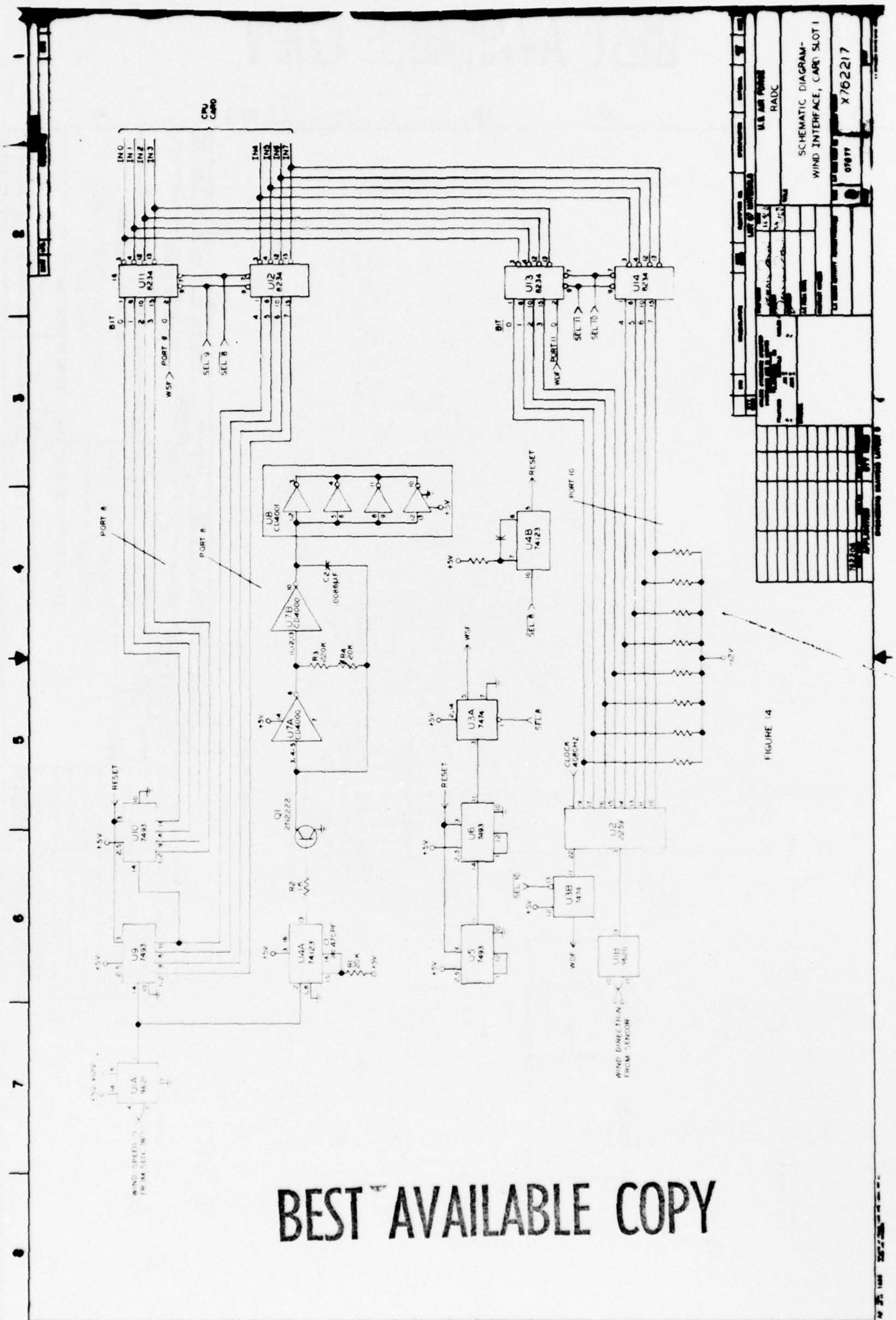

U.S. AIR FORCE
RADC
SCHEMATIC DIAGRAM-
WIND SPEED/DIRECTION
TRANSMITTER
X762211
LIST OF MATERIALS
ENGINEERING DRAWING LAYOUT C
MOTOROLA
2257L
ASTROSYSTEMS M6000
SYNCHRO/DIGITAL
CONVERTER
DV612
25HZ
CLOCK
FROM
WIND SPEED
TACHOMETER
APPLICATION

Figure 13


U.S. AIR FORCE
RADC
SCHEMATIC DIAGRAM-
WIND INTERFACE, CARD SLOT 1
X762217
FIGURE 4
CPU CARD
PORT 8
PORT 10
RESET
CLOCK
WIND SPEED
WIND DIRECTION

model M 6000. The parallel binary output of the converter is clocked out serially at a rate of 255 bits per second, with one start and two stop bits added to each reading. Thus there are 11 bits per character, including eight information bits, and approximately 25 characters are transmitted per second. The serial bit stream is fed to the twisted pair transmission line by a Fairchild 9621 differential line driver, and is received at the distant end by a 9620 line receiver. The differential line driver/receiver combination offers excellent protection from noise. The 9620 line receiver is specified to detect a signal of $\pm$ 500 millivolts in the presence of $\pm$ volts of common mode noise. Since each digital reading consists of eight bits, there are $2^8 = 256$ counts per shaft revolution, providing an accuracy of about $\pm$ 1.5^{o}, which is comfortably adequate for this application.

The wind speed converter (figure 15) incorporates a novel concept in digital conversion and transmission - delta sigma modulation. The heart of the delta sigma converter is a dual slope integrator whose inputs are (1)the negative DC voltage from the GMQ-20 tachometer and (2) an internally generated positive reference voltage that is switched in and out periodically. Referring to figure 15, assume that initially the analog switch is open, the output of the integrator is low, and the input and output of the D flipflop are low. Clock pulses are not being gated to the output line. Since the tachometer output is negative the integrator will integrate in the positive direction, charging the capacitor to the polarity shown. When the comparitor input passes ground potential, the state of the flipflop output Q changes on the next clock pulse. This has two results: (1) clock pulses will be gated to the line driver until the flipflop changes state again, (2) the reference voltage is switched into the integrator, causing it to integrate in the negative direction. When the input to the comparator goes negative, the gate to the line driver is closed, the reference

BEST AVAILABLE COPY

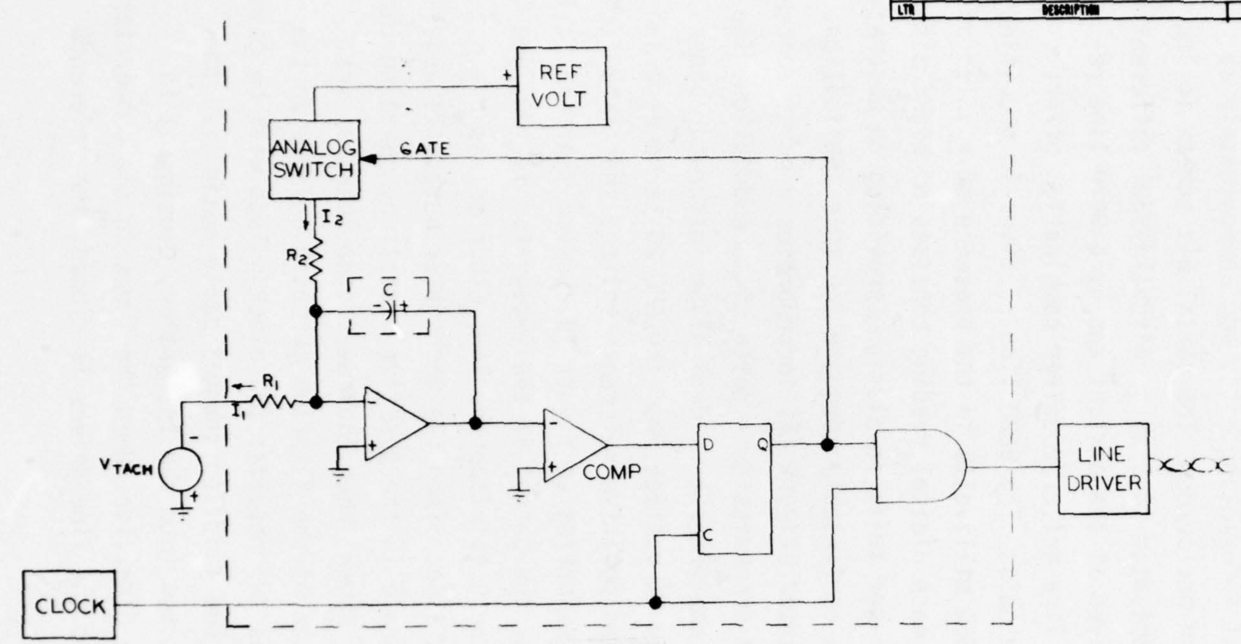


Figure 15

REVISIONS

PARTS LIST

APPLICATION

762206

U.S. AIR FORCE
RADC

SCHEMATIC DIAGRAM-
DELTA SIGMA MODULATOR

B 07877 X762210

AF FORM 1653 AUG 72 PREVIOUS EDITION WILL BE USED.

ENGINEERING DRAWING LAYOUT B

voltage is switched out, and the process repeats itself,

Consider a length of time T that is quite long relative to the time constants R1xC and R2XC. Define Nc to be the number of clock pulses that occur in time T and N_D to be the number of clock pulses that are gated out as data during time T. (In time T, the flipflop goes through many on-off cycles. It turns out that

$$\frac{N_D}{N_C} = \frac{R2xVtach}{R1xVref}$$

In fact, component values are calculated so that VrefxR1 = Vfull scale and

$$N_D = \frac{Vtach}{V\ full\ scale.}$$

There are apparent sources of error. However, one of the strengths of delta sigma modulation is that most of these errors can be eliminated or, in fact, tend to cancel themselves out. Although

$\frac{N_D}{N_C}$ depends

on the values of R1 and R2, note that

$\frac{N_D}{N_C}$ is actually proportional

to the ratio $\frac{R2}{R1}$. It is reasonable to expect that a 5% change in the resistance of R2 brought about by environmental conditions would be accompanied by a like change in the value of R1. Notice that the value of the capacitor is a "don't care" since it does not appear in the equation for $\frac{N_D}{N_C}$

IC 2 of figure 13 is a Hybrid Systems DV 612, which contains all of the circuitry shown in figure 15 except C. In the receiving unit (figure 14) wind speed pulses are counted for a 1 second period similar to the transmissometer interface. However, the clock (IC 7) is synchronized by the incoming wind speed signal, eliminating the need for great accuracy and stability. the timing counter chain (U's 3,5,6)

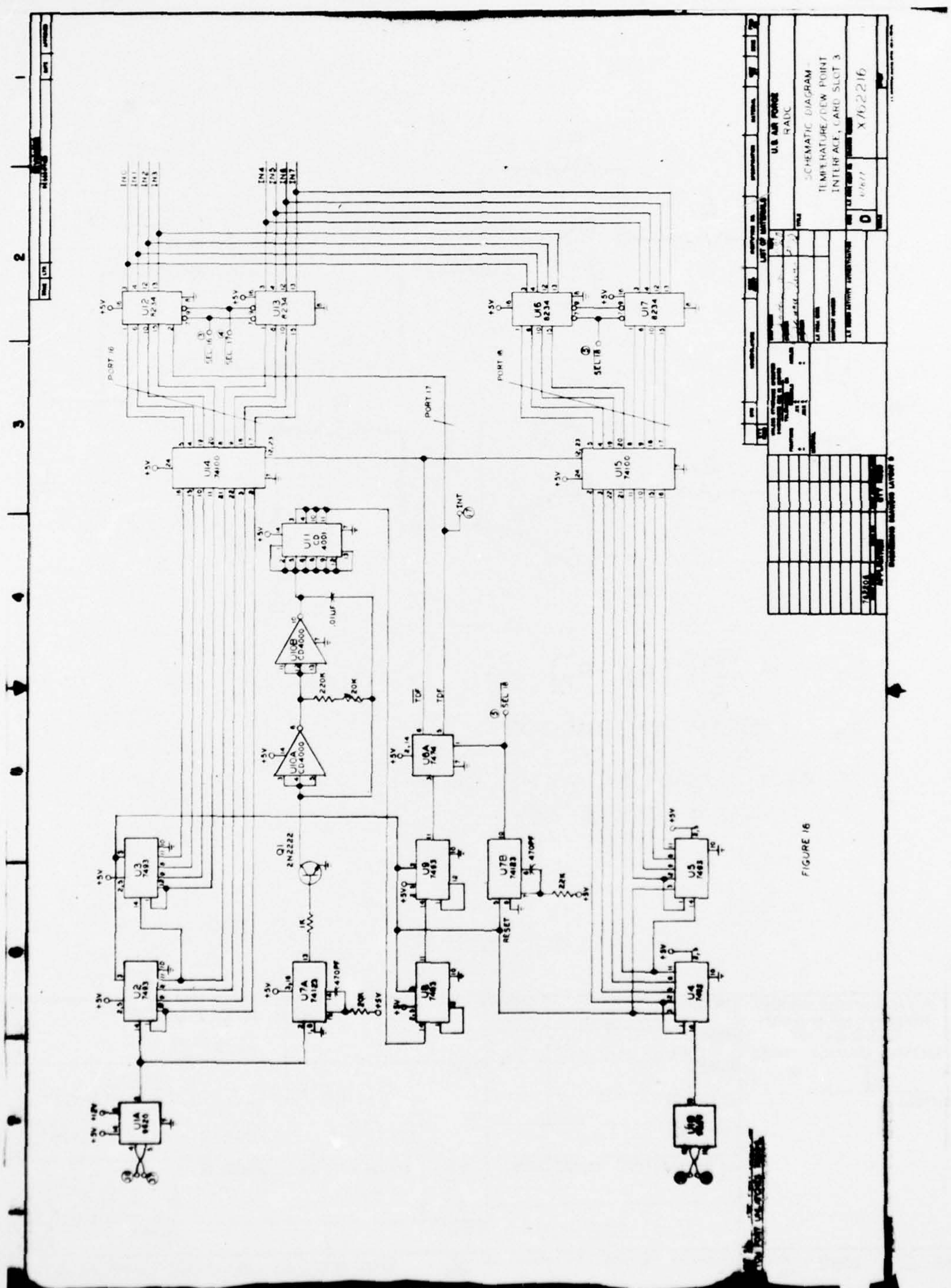
(U's 3, 5, 6) interrupts the processor at every 256th clock pulse, and the processor reads a new byte of wind speed data.

The wind direction samples are received and serial-to-parallel converted by U 2, the Motorola Me 2259 terminal receiver (essentially the receiving half of a UART). The processor is interrupted to read a byte of data 25 times per second, every time a complete byte with stop bits has been received.

3.2.4 Temperature/Dew Point

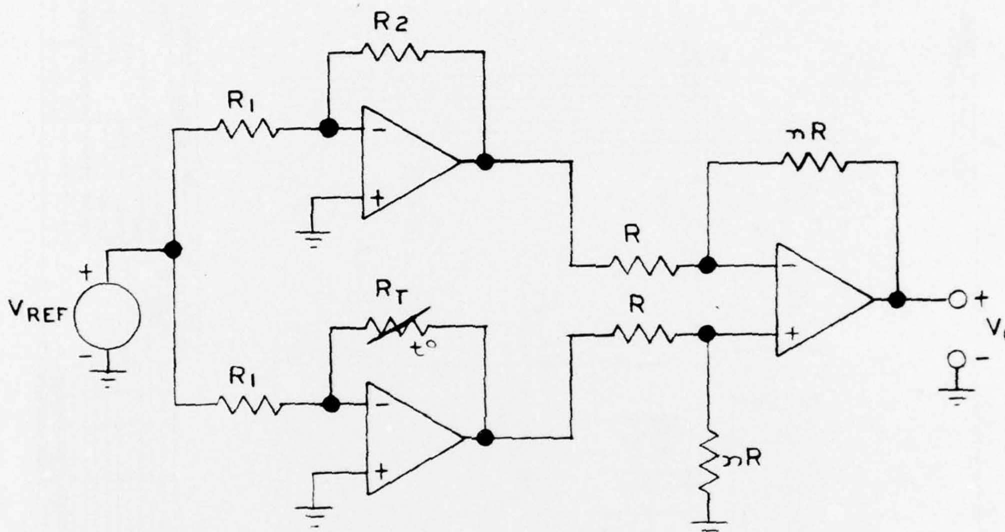
The temperature/dew point interface unit shown in figure 16 will not be discussed in detail, since it is very similar to the wind speed interface. However, the converter shown in figure 17, colocated with the sensor, bears some discussion. An effort was made to digitize the output of the TMQ-11 sensor, with unfavorable results. The temperature sensing thermistor in the TMQ-11 varies from 77.6 ohms to 119.6 ohms as temperature varies from -80^{o}F to 130^{o}F. This is a change of 42 ohms for a temperature range of 210^{o}F, or .2 ohms per degree F. One way to get a signal out of the sensor is to drive a constant current through it so that the voltage across the thermistor varies in proportion to its resistance. However, the current must be kept small to prevent heating of the thermistor. If a constant current of 5 ma is used, the output signal will swing 5 x 42 = 210 millivolts over the temperature range of interest. To drive a delta sigma modulator or any other reasonable modulation scheme with any degree of accuracy requires an input signal swing of a few volts. To get a signal of 5 volts, we would need an amplifier with a gain of 5 volts/ 210 millivolts = 24.

Designing such an amplifier with sufficient accuracy would be extremely difficult, if not impossible. While it might be possible to digitize the output of the TMQ-11, the system would be expensive, inaccurate, and difficult to calibrate.


U.S. AIR FORCE
RADC
SCHEMATIC DIAGRAM
TEMPERATURE/DEW POINT
INTERFACE, CARD SLOT 3
FIGURE 18

BEST AVAILABLE COPY

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED



$$V_0 = -n \frac{V_{REF}}{R_1}\left[R_2 - R_T\right]$$

R_T = LINEAR THERMISTOR

IF R_2 = MAXIMUM VALUE OF R_T:

$$V_o = \frac{n V_{REF}}{R_1} \Delta R_T$$

FIGURE 17

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
± .XX± ±
.XXX±

MATERIAL

DRAFTSMAN | DATE
CHECKER
ENGINEER
A.F. PROJ. ENGR.
CONTRACT NO.
A.F. DESIGN ACTIVITY AUTHENTICATION

D/L 762206

U.S. AIR FORCE
RADC

TITLE
SCHEMATIC DIAGRAM-
BRIDGE SURROGATE CIRCUIT

SIZE A | A.F. CODE IDENT NO. 07877 | DRAWING NO. X762208

SCALE | SHEET

AF FORM 1652 SEP 65 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

ENGINEERING DRAWING LAYOUT A VERTICAL

A better approach appears to be replacement of the TMQ-11 or replacement of the sensing elements in the TMQ-11. A likely replacement for the TMQ-11 is the temperature/dew point sensor designed by National Weather Service for their Remote Automated Meteorological Observation Station (RAMOS). The RAMOS sensor uses sensing elements from Yellow Springs Instrument Company - linear thermistors with a resistance change in the neighborhood of 130 ohms per degree C. A sensor of this type can be made part of a bridge-surrogate circuit* as in figure 17.

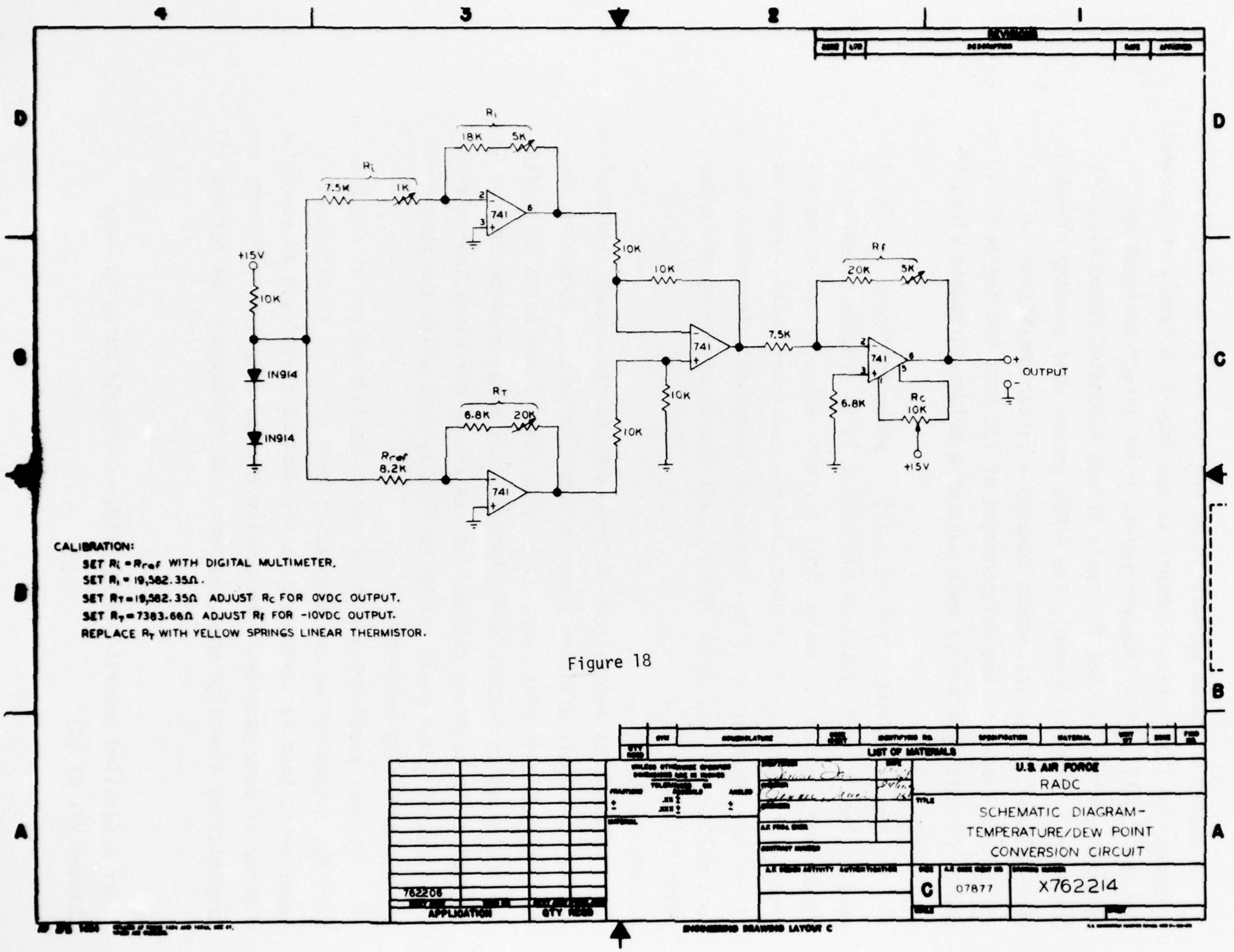
An operating model that we built is shown in figure 18. The purpose of the forward-biased IN 914 diodes is to provide a Vref of 2 diode drops, about 1.4 volts. This circuit, which proved to be extremely accurate, could be used with the component values shown for either the temperature or the dew point thermistor. The output is fed to a delta-sigma modulator for transmission to the temperature/dew point interface unit.

4. CONCLUSIONS

The goals of automation, as addressed in this study, are twofold: first, to improve efficiency and reliability through automatic dissemination and display; second, to save development costs by retaining the existing sensors while reducing cable maintenance expense by replacing the existing cables. The results of the study indicate that the first of these goals can be completely met, while the second can be only partially achieved.

The most promising aspect of the automation effort is the processing, dissemination and display of data after it is digitized. A computer is good at performing easily defined tasks such as averaging a group of data samples, transcribing digital data into a format, and transmitting a message when queried. A microprocessor can perform all

* For a detailed description of bridge-surrogate circuits, see Chapter VII of (8).



CALIBRATION:

SET $R_i = R_{ref}$ WITH DIGITAL MULTIMETER.

SET R_1 = 19,582.35Ω.

SET R_T=19,582.35Ω ADJUST R_C FOR OVDC OUTPUT.

SET R_T=7383.66Ω ADJUST R_f FOR -10VDC OUTPUT.

REPLACE R_T WITH YELLOW SPRINGS LINEAR THERMISTOR.

Figure 18

all of these roles.

Digitizing the signal at the sensor to retain the existing sensor and permit replacement of cables was more successful with some sensors than others. In the instances where digitization at the sensor does not appear promising, it is generally because the existing sensor can not be functionally isolated from the existing indicator.

Sensors that fall into this category are the AN/GMQ-13 Rotating Beam Ceilometer, the AN/TMQ-11 Temperature/Dew Point Sensor, and the wind direction segment of the AN/GMQ-20 Wind Instrument. There doesn't appear to be any convenient way to digitize the RBC detector output signal at the sensor, because the digitization process requires timing from the computer (see para 3.2.2). It does not appear practical to digitize the output of the AN/TMQ-11 sensing unit, primarily because the sensing elements resistance variation over the temperature range is inadequate. A better approach would be adoption of a new sensor such as that used in the National Weather Service's RAMOS system (see para 3.2.4). The synchro-to-digital conversion technique used for the wind direction portion of the AN/GMQ-20 was partially successful, in that the signal produced by the wind direction converter can be transmitted over any type of cable. However, synchro-to-digital converters are fairly costly ($300-400), and are normally specified for operation over commercial temperature range, necessitating some sort of temperature control for this application.

For sensors that can be functionally isolated from their indicators, digitization at the sensor seems feasible. Sensors of this type are the transmissometer and the wind speed segment of the AN/GMQ-20. Replacement of the transmissometers cable could be made possible quite easily by moving two or three components of the transmissometer interface out to the transmissometer as discussed in para 3.2.1. The wind speed sensor presents no special problems, since the

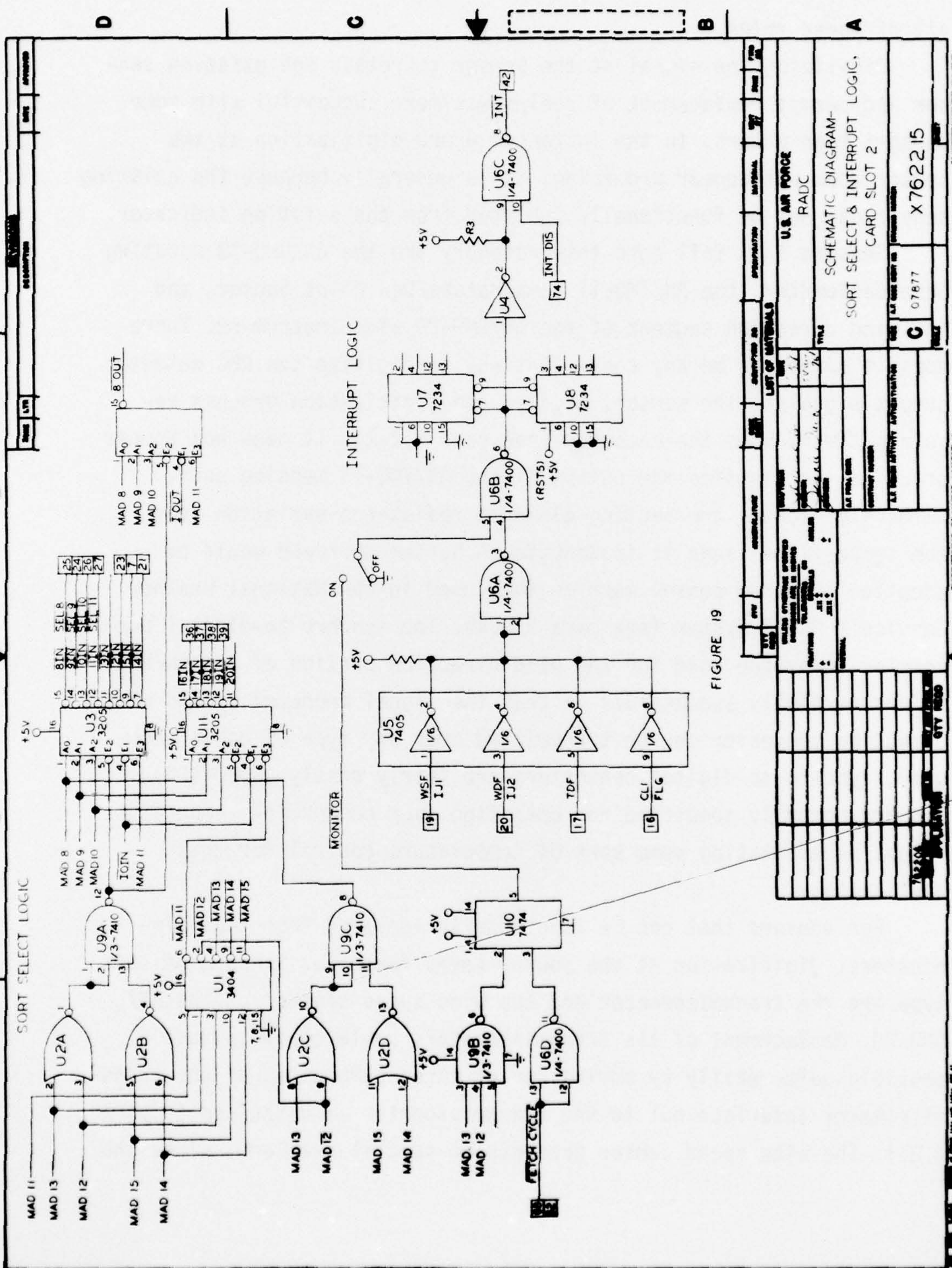

SORT SELECT LOGIC
INTERRUPT LOGIC
U.S. AIR FORCE
RADC
SCHEMATIC DIAGRAM-
SORT SELECT & INTERRUPT LOGIC,
CARD SLOT 2
07877
X762215
MONITOR
FETCH CYCLE

FIGURE 19

wind speed converter colocated with the sensor is simple and inexpensive, and its delta-sigma modulated output signal can be transmitted over any type of cable.

Perhaps the portion of the effort that shows the greatest promise of success is the elimination of the AN/FMN-1 Computer. The description of the transmissivity/RVR subsystem in para 3.2.1 shows that a microprocessor and a small amount of memory can do the job of the AN/FMN-1. In fact, this is a text-book microprocessor application that should result in significant cost savings.

The results of this study indicate that an automated, microprocessor-based system is feasible, and would provide major improvements, particularly in the area of dissemination and display. While it appears that some of the existing sensors could be made part of an automated system, the questions of whether to replace sensors or buy or develop new ones should be referred to AFGL/LYU, where these questions are being investigated further.

REFERENCES

(1) GEEIA Meteorological Conference Report
23 - 25 July 1968 Griffiss AFB NY

(2) T.O. 31 M1-2GMQ10-61, 1 Feb 1966

(3) T.O. 31 M1-2FMN1-2, 30 Jun 1966

(4) T.O. 31M5-2GMQ20-2, 1 Aug 1970

(5) T.O. 31M4-2TMQ11-2, 15 Mar 1960

(6) T.O. 31M1-2GMQ13-12, 15 Dec 1960

(7) R De Freitas, "The Low Cost Way to Send Digital Data", <u>Electronic Design</u>, 18 January 74

(8) John I Smith, <u>Modern Operational Circuit Design</u>, Wiley, 1972

☆U.S. GOVERNMENT PRINTING OFFICE: 1977-714-025/166

METRIC SYSTEM

BASE UNITS:

Quantity	Unit	SI Symbol	Formula
length	metre	m	...
mass	kilogram	kg	...
time	second	s	...
electric current	ampere	A	...
thermodynamic temperature	kelvin	K	...
amount of substance	mole	mol	...
luminous intensity	candela	cd	...

SUPPLEMENTARY UNITS:

plane angle	radian	rad	...
solid angle	steradian	sr	...

DERIVED UNITS:

Acceleration	metre per second squared	...	m/s
activity (of a radioactive source)	disintegration per second	...	(disintegration)/s
angular acceleration	radian per second squared	...	rad/s
angular velocity	radian per second	...	rad/s
area	square metre	...	m
density	kilogram per cubic metre	...	kg/m
electric capacitance	farad	F	A·s/V
electrical conductance	siemens	S	A/V
electric field strength	volt per metre	...	V/m
electric inductance	henry	H	V·s/A
electric potential difference	volt	V	W/A
electric resistance	ohm		V/A
electromotive force	volt	V	W/A
energy	joule	J	N·m
entropy	joule per kelvin	...	J/K
force	newton	N	kg·m/s
frequency	hertz	Hz	(cycle)/s
illuminance	lux	lx	lm/m
luminance	candela per square metre	...	cd/m
luminous flux	lumen	lm	cd·sr
magnetic field strength	ampere per metre	...	A/m
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m
magnetomotive force	ampere	A	...
power	watt	W	J/s
pressure	pascal	Pa	N/m
quantity of electricity	coulomb	C	A·s
quantity of heat	joule	J	N·m
radiant intensity	watt per steradian	...	W/sr
specific heat	joule per kilogram-kelvin	...	J/kg·K
stress	pascal	Pa	N/m
thermal conductivity	watt per metre-kelvin	...	W/m·K
velocity	metre per second	...	m/s
viscosity, dynamic	pascal-second	...	Pa·s
viscosity, kinematic	square metre per second	...	m/s
voltage	volt	V	W/A
volume	cubic metre	...	m
wavenumber	reciprocal metre	...	(wave)/m
work	joule	J	N·m

SI PREFIXES:

Multiplication Factors	Prefix	SI Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto*	h
10 = 10^{1}	deka*	da
0.1 = 10^{-1}	deci*	d
0.01 = 10^{-2}	centi*	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

* To be avoided where possible.

MISSION
of
Rome Air Development Center

RADC plans and conducts research, exploratory and advanced development programs in command, control, and communications (C^3) activities, and in the C^3 areas of information sciences and intelligence. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976